To Dr Bryant,
With all good wishes for 1924.
Mary E. Reid.

Bacteriology in a Nutshell

A Primer for Nurses

COMPILED AND ARRANGED BY

MARY E. REID, R. N.

Superintendent Thomas Hospital Training School for Nurses, Charleston, W. Va., 1898-02; Assistant Instructor in General Nursing, Woman's Branch of the Deaconess Hospital, Cincinnati, O., 1904; Principal of the Training School and Superintendent of Nurses, Charleston General Hospital, Charleston, W. Va., 1905-07.

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DEDICATION.

To Charlotte A. Aikens, Author of Hospital Housekeeping; Training School Methods and The Head Nurse, Primary Studies for Nurses and other valuable books for Nurses, to whose suggestion this booklet owes its origin; to my dear friend and old Superintendent, Sister Emilié Koch, of the Deaconess Hospital, Cincinnati, Ohio; and to my sister nurses throughout the world, "Bacteriology in a Nutshell" is most affectionately dedicated.

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CONTENTS.

CONTENTS.

SUPPLEMENT.

INTRODUCTION TO TENTH EDITION.

As each new edition of BACTERIOLOGY IN A NUTSHELL is published, it is the aim of the editor and compiler to have that edition contain anything of importance that has developed along bacteriological lines since the preceding edition.

In 1914 BACTERIOLOGY IN A NUTSHELL was translated into Chinese by an American nurse, Miss Nina D. Gage, R. N., of New York, who is Superintendent of Nurses in a hospital in Shangshi, China. It is a source of gratification to know that since then the book has been adopted by the American Graduate Nurses' Association in China as their text-book for nurses in training-schools in that country.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. Va., August 1, 1920-1922.

INTRODUCTION TO EIGHTH AND NINTH EDITIONS.

In this, the eighth edition of BACTERIOLOGY IN A NUTSHELL, the subject matter contained therein has been very carefully reviewed and amended. Suggestions for additions in order to make the book more widely useful, not only for pupil nurses in training-schools, but, also, for the graduate nurse on duty, as a reference book, were received from various sources during the past year. These suggestions have been borne in mind and have been of great service during the work of reviewing and revising. To those who have found the book of sufficient importance to write personally of its value in their work, many thanks are due.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. Va., Sept. 1, 1917-1918.

INTRODUCTION TO SEVENTH EDITION.

So short a time has transpired since the publication of the Sixth Edition that revision seems unnecessary. Nothing of special interest to nurse students of Bacteriology has materialized in these few months.

It may be of interest to those who are engaged in training nurses in foreign fields to know that "Bacteriology in a Nutshell" is this year to be translated into the Chinese language by a superintendent of nurses in a Chinese training school and will be used as a textbook for student nurses in China.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. Va., September 1, 1914.

INTRODUCTION TO SIXTH EDITION, REVISED.

In July, 1904, Bacteriology in a Nutshell first saw the light of day. It was then published as a small text-book for junior nurses and contained but one hundred and ten (110) pages. At that time it was the only text-book for nurses on the subject of bacteriology in the United States. Many were in existence for medical students. The writer received letters of congratulation from Superintendents of Nurses and from graduate nurses in private practice all through the different states and Canada, who welcomed the little book because it "filled a long-felt want," as they expressed it. The demand for the first edition and the later editions which succeeded it has been almost phenomenal. As each new edition is brought out the text is revised and amended in order to give pupil nurses the benefit of recent knowledge gained by advanced workers along bacteriological lines. The science of bacteriology is still young and new things concerning its mysteries are being brought to light all the time. For this reason, as students of a so vastly interesting and instructive branch

of our work, we must *keep in touch* with those who make the observation of the habits, etc., of bacteria their life-work.

To the many friends of Bacteriology in a Nutshell, from whom as the years go by numberless kind letters of appreciation are received, most sincere thanks are due.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. VA., October 1, 1913.

INTRODUCTION TO FOURTH EDITION REVISED.

During the past year there has come to me from many of the superintendents of hospital training schools who use "Bacteriology in a Nutshell" in their class work the request: "Please add a chapter on serum therapy." This request has been repeated by numerous graduate nurses who use the book for reference outside the training school. Some of these nurses are interested in the study of the "Side Chain Theory of Ehrlich" and its relation to immunity, and have asked that this subject, also, be included.

My object in preparing the book, "Bacteriology in a Nutshell," was to have it a very simple one for young nurses just taking up the study. Ehrlich's hypothesis is a complex one and its study is not adapted to the young nurse, for whose use my small book is intended. For the older nurses in our ranks, who will always be students, it is an interesting and fascinating subject. I have not thought it best, for the reason just stated, to incorporate it into the book proper, but have added it in a supplement introducing serum therapy. I have not had the time at my disposal, since these requests

came, to give either subject the careful thought it deserves. Yet, if those who have desired these additions, find the supplement to be of sufficient interest to induce them to look into the matter touched upon therein more fully, I shall feel more than repaid for the extra work attempted.

My most sincere thanks are due to Dr. H. L. Robertson, lecturer on Bacteriology, the Charleston General Hospital, Charleston, W. Va., for a synopsis of Ehrlich's hypothesis and for information and bulletins concerning serum therapy. Also, for much assistance in reviewing the proof and for corrections therein.

To Dr. V. T. Churchman, lecturer on the Eye, Ear, Nose and Throat, the Charleston General Hospital, I am also indebted for the report of a case cured by the serum treatment at the Charleston General Hospital.

To Dr. A. A. Shawkey, of the surgical staff, the Barber Hospital, Charleston, I also owe my thanks for literature and for the report of another interesting case cured by serum therapy at the Barber Hospital.

A second request that has come to me during the past year is the following: "Please tell us when you think pupil nurses should begin the study of bacteriology? How much laboratory work should they be taught and who should be their instructor?" With regard to the first question, my reply is this: They should begin to receive *practical instruction* the instant they

dawn on your horizon as probationers. This instruction to be supplemented by class work and broadened by the lecture course, should you retain them as pupil nurses. If they are never retained beyond the period of probation, the practical lessons you have imparted will not be wasted. Probationers are *unsafe* to carry out any part of hospital routine without such practical instruction under a competent head nurse.

As to laboratory work. Teachers agree that much laboratory instruction is unnecessary for the average pupil nurse. Aside from care and use of laboratory equipment and simple, practical demonstrations, it is my opinion that laboratory work should *not be compulsory.* As to who shall be the instructor. If you are so lucky as to have a sensible, enthusiastic bacteriologist in charge of your laboratory, let your pupils serve a period in the laboratory just as they do in all other departments of the hospital. The length of period to be such as will enable them to become familiar with the use and care of the microscope; use and care of the sterilizer and of all dishes, tubes, slides, flasks, cover glasses, platinum rods, forceps, etc., used in laboratory work. A great many of the laboratory tests take too much of a nurses' time to study out intelligently and are only of value *to a nurse* should she intend to become a teacher of the subject in the training school and not one in a hundred has this desire.

Therefore, may I repeat, do not make such parts of laboratory work *compulsory* as have taken bacteriologists years to evolve and perfect. Object lessons, such as observation and examination under the microscope of dust and sweepings from wards and rooms and scrapings from beneath finger nails, will impress upon them why we preach "dust and dirt mean danger." Observation, also, in the same way of the different forms of bacteria and their subdivisions, of water, sterilized and unsterilized, of milk straight from the dairy and also of pasteurized milk, etc., are all practical lessons. Another object lesson worthy of attention is the microscopic examination of the common household fly, now-a-days known as "the typhoid fly." Have you had pupil nurses remove screens from your hospital windows, or open windows several inches above the screens (if your screens did not cover the entire window)? Have a nurse catch just one fly that this act of carelessness, or thoughtlessness, has admitted. Let her examine it under the microscope. Turn it over on its back and let her see the construction of its feet. Each foot is equipped with pads and claws; two pairs on each foot. Each of these pads is covered with many thousands of sticky hairs to which millions of disease germs have adhered as the fly has feasted on the filth it loves and which it has had no trouble to find on the premises of the

uncleanly. Straight from this feasting it has come in at the open window and it shakes and rubs this deadly cargo from off its feet wherever it will. Part of it is washed off with its tongue and swallowed. Increased a millionfold the germs are passed off in excreta. This excreta the fly deposits on the food in your diet kitchen, in the milk pitcher and where not? Such an object lesson the conscientious, painstaking pupil will *never* forget. As to the pupil who is neither, the time to begin to teach her bacteriology, or anything else in our training school course is "away back with her grandmother." Teaching the simpler laboratory work comes within the province of the superintendent of nurses, or the head nurse. The more difficult part belongs to the bacteriologist.

Mary E. Reid, R. N.,

Charleston-on-Kanawha, W. Va.,
August 1, 1910.

INTRODUCTION TO THIRD EDITION.

Again are my thanks due to the Training-School Superintendents and to the graduate nurses who have made the sale of the second edition of Bacteriology in a Nutshell so successful. For many words of praise received from these sources I am deeply grateful. In this the third edition, no changes have been made in the text, with the exception of brief mention of the work of the Yellow Fever Commission in Havana, Cuba, in 1900. For literature concerning the work of this noble band of investigators, I am indebted to Dr. Wm. A. MacMillan, of the MacMillan Hospital, Charleston, W. Va., to whom I desire to express my thanks and appreciation.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. Va., January 1, 1909.

INTRODUCTION TO REVISED EDITION.

The kindly reception given to the first edition of Bacteriology in a Nutshell, by Superintendents of training-schools for nurses and by graduate nurses throughout the United States, has been much appreciated by the author. In revising and enlarging the primer all authorities have been consulted. The book is now sent forth with the hope and expectation that teachers and pupils in training schools may find it more than ever helpful.

My thanks are again due to Dr. Zinke, of Cincinnati, Ohio, for a careful review of the revised portions of the primer; to Miss Aikens, of the National Hospital Record, and to Dr. John E. Cannaday, of Sheltering Arms Hospital, W. Va., for valuable advice during the work of revision, and to Dr. Charles O'Grady, of the Charleston General Hospital, Charleston, W. Va., for information and clipping concerning the opsonic theory.

MARY E. REID, R. N.,

Charleston-on-Kanawha, W. Va., October, 1907.

BACTERIOLOGY IN A NUTSHELL.

FIRST EDITION.

INTRODUCTORY.

In compiling this small primer of bacteriology for junior nurses, the work along bacteriological lines prepared as one of the members of the class of students of "The Graduate Nurses' Hospital Extension Course," in October, 1903, has been used as a basis. Nothing new in the way of theory has been attempted. Much rather would the writer join the ranks of her sister nurses who so bravely have enlisted to help the noble army of physicians and surgeons fight a victorious warfare against that branch of the bacteria family called "disease germs." Most gladly would we all as nurses see these tiny foes to health destroyed forever.

Superintendents of training schools have realized for some years that a few easily comprehended lessons on bacteriology for junior nurses are necessary. The sole aim of "Bacteriology in a Nutshell" is to present to young nurses just starting out in the study of the germ theory of disease some of its principal teachings as briefly and as simply as possible. If the contents of this booklet have been made sufficiently clear, so as to be easily grasped by those for whose benefit it is intended, and if it serves as an incentive to further study and

research into this most interesting and useful branch of science, the result will be more than gratifying to the writer and of lasting benefit to student nurses.

Much assistance has been obtained from a review of the work of hospital training school days and notes of lectures of Dr. E. Gustave Zinke, Dr. Magnus A. Tate and Dr. James W. Rowe, particularly lectures with regard to Sepsis, Asepsis, Antisepsis, Infection, Disinfection, Sterilization, etc. In addition to these helps, my own experience of recent years as a teacher in training schools has proven of material benefit.

My thanks are especially due to Dr. James W. Rowe for valuable information with regard to the discoverers of bacteria, given to me since beginning the preparation of the primer, and also for helpful suggestions during the work of proof reading; to Miss Aikens, of the National Hospital Record, for assistance in outlining the plan of the book; to Miss Susie L. Wanzer, one of the old pupils of the Thomas Hospital Training School for Nurses, Charleston, W. Va., who so efficiently assisted in preparing the manuscript for publication, and who also made for me the drawings for cuts representing the forms of bacteria mentioned in the text.

MARY E. REID, R. N.,

Cincinnati, O., July, 1904.

MODIFIED OATH.

Modified Hippocratic Oath.

THE principles set forth in the following "modified oath," which the nurses of the Brooks Memorial Hospital, Dunkirk, N. Y., and other hospital training-schools, are required to take at their graduation exercises, deserve a place opposite the initial page in exery text-book written for nurses:

"I solemnly promise and swear that in the practice of my profession I will always be loyal to the patients entrusted to my care and to the physicians under whom I shall serve. That I will not make use of nor recommend any quack or secret nostrum. That I will be just and generous to members of my profession, aiding them when they shall need aid and I can do so without detriment to myself or to my patients. That I will lead my life and practice my profession in uprightness and honor. That I will not lend my aid to any criminal or illegal practice whatever. That into whatever house I shall enter it shall be for the good of the sick to the utmost of my power. That whatever I shall see or hear of the lives of men and women, whether they be my patients or members of their households, that will I hold inviolably secret and that I will continue to observe and to study and will strive in every way for the improvement of my profession; not regarding it as a means of livelihood alone, but as an honorable and upright calling."

To be LOYAL, to be HONORABLE, to be JUST, to be GENEROUS, to be PURE, to be UPRIGHT, to be TRUSTWORTHY and "NOT A MEDDLER in other men's matters," to be OBSERVANT, to be TACTFUL, to be STUDIOUS, all these are principles which, if they do not already possess them, should be instilled into the minds of all young women from the day they enter the training school until they leave it. All are links of grave import in the chain of "qualifications of a good nurse" as well as stepping-stones toward becoming "a perfect woman nobly planned."

M. E. R.

Bacteriology in a Nutshell.

CHAPTER I.

BRIEF HISTORY OF BACTERIOLOGY.

Definition.

Bacteriology is that branch of science which teaches us the evils of disease producing micro-organisms, and the benefits derived by the animal world from another class which is antagonistic to disease.

Earliest Mention.

The history of bacteriology may be traced back to the seventeenth century. Some authorities, indeed, tell us that at as early a date as the time of Cæsar, 116-27 B. C., there lived a Roman author, Varro by name, who wrote of very tiny living "creatures" which were invisible to the naked eye, and yet they by some means gained an entrance into the system and "caused diseases difficult to treat." Almost two thousand years roll by before we learn of the germ theory of disease being again touched upon, then, in the eighteenth century, it is advocated by Plenčiz, of Vienna.

Perfection of Single Lens.

In the year 1675 we are told that Antonious Von Leeuwenhoek, of Holland,* proclaimed to the world the perfection of his single lens by means of which he had brought to light "living, moving animalcules" in rainwater. So very

*Leeuwenhoek was born in Delft, Netherlands, in 1632; died in 1723,

tiny were these objects that millions of them were found to exist in a single drop.

Leeuwenhoek's Announcement.

The researches of Leeuwenhoek were continued and in 1683 the world received another announcement—the discovery under the compound microscope of a special form of bacteria in the scrapings of teeth and in saliva. This scientist presented the results of his work of research to the *Royal Society of London, England; suitable engravings accompanied the gift. We are not told whether Leeuwenhoek in any way connected the germs he discovered with disease causation; the supposition of authorities is that he did not.

No attempt was made to classify, separate or identify the germs discovered by Leeuwenhoek, although many noted scientists of that century believed them to be the cause of certain changes in the tissues of the human structure. It was not until the year 1762 that Antonius Plenciz, a physician of Vienna, began ascribing to the micro-organisms discovered by Leeuwenhoek the power to produce the so-called infectious diseases.

Theory of Plenciz.

The theories advanced by Plenciz were these:

I.—That the material which caused the infection was a living substance;

II.—That this living substance multiplied

* Leeuwenhoek was chosen Fellow of the Royal Society of London in 1685.

within the system, and that it could be thrown off by individuals and carried by the air to others;

III.—That each separate infectious disease was brought into existence by a special germ which could cause no other disease; contending, in order to uphold his belief, that as only one kind of grain can grow from one kind of seed, so, also, only one disease can be produced by one form of germ or micro-organism.

The theory that disease germs were living things capable of growth and reproduction did not, at this time, gain favorable consideration, and it was not again advanced until almost sixty years had elapsed. In the year 1821, *Henle an anatomist and scientist of Germany, gave expression to the conviction of the truthfulness of the theory, but only to be met with the opposition which defeated Plenciz. Henle, however, is said to have successfully met and overcome all the objections of his opponents, and shortly after this time the relation of micro-organisms to disease was scientifically proven although many still remained skeptical.

Plenciz's Theory Proven.

One point over which there was a great deal of discussion during the century and a half between the discoveries of Leeuwenhoek and

* F. Gustav Henle, born at Furth, Bavaria, 1798; died at Göttingen, 1885. Was professor at Zurich, 1824; Heidelburg, 1844, and at Göttingen, 1852.

the acceptance of the theories of Plenciz through the demonstrations of Henle, was the *origin* of these germs. "Do they generate spontaneously or are they the descendants of pre-existing creatures of the same kind?

Theory of Schulze.

*Karl H. Schulze, also of Germany, was the first to throw light on this rather mystifying question. In 1836 he demonstrated the fact that "if the air which gained access to the material which was being experimented upon could be made to pass through strong acid or alkaline solutions decomposition would not take place." Other scientists began to work along the same lines and obtained similar results. Their experiments, for the most part, were made upon wounds and their infections. They made no attempt to reproduce the infectious diseases by inoculation, which is the method used in our day. Numbers of scientific men of that period believed the presence of micro-organisms in the blood and tissues of individuals to *be a normal condition.* Others urged that the micro-organisms found in diseased conditions were the *result of the disease* and *not its cause.*

A number of years passed before the work of discovering a special germ for each infectious disease made much progress.

* Karl Heinrich Schulze, physician and anatomist, born at Ault, Ruppin, in 1798. Professor at Berlin in 1833.

Proclamation of Semmelweis.

In 1847 Ignatius P. Semmelweis, a young Hungarian pursuing his studies in Vienna, proclaimed to the world one of the greatest discoveries ever made along bacteriological lines, namely, that puerperal sepsis is the result of the invasion of the puerperal genital tract by specific micro-organisms and from that year a new era in obstetrical practice is dated.

Semmelweis, among other medical students, was allowed to assist at births in the maternity wards of a large general hospital in Vienna where there were also a number of midwives employed. Semmelweis soon observed that a large mortality, about fifteen per cent (15%) occurred in the student's clinic, and almost invariably from puerperal fever. In the clinics in charge of the midwives the mortality rate was very low in comparison, only about 1.5 per cent. He began to study into the reason for the greater success of the midwives. He soon had cause to suspect that the dissecting-room work of the students was at the root of the trouble. One of his fellow-students died from the effects of an infected finger, which he had cut during a post-mortem. The symptoms in this case were so similar to those observed in the deaths due to puerperal fever in the maternity wards that Semmelweis's eyes were opened to the dangerous practice of the students who often went directly from the dissecting-room to their

cases in the maternity wards, with little thought, apparently as to the condition of their hands. Semmelweis immediately began to scrub and disinfect his own hands before approaching the beds of his maternity cases, and soon found his efforts crowned with success. Then he insisted upon his fellow-students practicing the same routine. The mortality rate in the students' clinic thereafter became much less than that of the midwives. The disinfectant used by Semmelweis and his co-workers was chlorine solution. In spite of the success of this conscientious worker, there was much skepticism with regard to his theory, and he died in an insane asylum, his malady the result of worry over unfriendly *criticism.*

Chlorine Solution Our First Disinfectant.

In 1849 the bacillus anthracis, the germ which causes anthrax, was discovered by Pollender, of Germany, but it was not until the year 1863 that *Casimir Joseph Devaine, a Frenchman, by the process of inoculation proved that Pollender's germ really produced anthrax.

Pasteur's Experiments.

In 1862 †Louis Pasteur, of France, the fame of whose work at "Pasteur Institute," Paris, is world wide, first began his experiments to prove that living organisms are in the air we

* Casimir Joseph Devaine, born at St. Armand-les-Eaux, France, in 1812; died in 1882.

† Pasteur was born at Dôle, Jura, France, in 1822; died in 1895.

breathe, in the food we eat, upon the clothing we wear, in the dust we tread beneath our feet, and that they may be found any place where dust settles. It had long been contended that the processes of fermentation and putrefaction were purely chemical processes and not the work of micro-organisms. This theory Pasteur's experiments proved to be erroneous. It was proven also through the experiments of Pasteur that the reproduction of bacteria takes place by processes similar to those which cause the reproduction of larger vegetable or plant life and not by spontaneous generation. Many other important discoveries are credited to the experiments of Pasteur. In fact, the most scientific men of the present day go so far as to say that the real history of bacteriology dates no farther back than to the experiments and discoveries of Pasteur; that while it was not he who first discovered the existence of germ life, nor who first studied bacteria, nor who first suggested their connection with fermentative processes and with diseases, yet it is to his experiments we owe the placing of bacteriological study upon a firm basis, and that all the history of micro-organisms which antedates the experiments and discoveries of Pasteur is merely theoretical, more likely to be erroneous than otherwise.

Errors Lessened by Pasteur.

In 1872 Klebs began to teach that general sepsis is caused by bacteria invading the blood.

Klebs is of German birth; he was born in Koenigsberg; he was educated at Berlin, and later in life (1882-92) was professor at Zurich.

In 1873 the micro-organism of relapsing fever was discovered. To Obermeier, of Germany, belongs the credit for this discovery.

Dawn of Antisepsis.

In 1875 the germ theory of disease was pretty generally accepted, at least by the scientific world. In that year Lord Lister, an English surgeon, who later (1877) was professor in King's College, London, began the use of antiseptics in surgery. He had been suspicious of the cause of suppuration in wounds as early as the year 1867. He based his experiments upon the discoveries of Pasteur. Carbolic acid solution was the first substance used by Lister in his surgical operations, and thus was ushered in the era of antiseptic surgery. Less than half a century has passed, and yet to what gigantic proportions has grown the use of substances to either destroy germs or to prevent their doing mischief by stopping their growth! Carbolic acid solutions still remain in common use.

The bacillus of leprosy,* *the bacillus leprae,*

*In July, 1904, Rost, of the medical staff in India, reported that he had succeeded in cultivating the bacillus of leprosy and from the cultures had made a substance he called "leprolin," which, when injected into the tissues of lepers, had a marked beneficial effect. Later statistics, 1912-1913, place but little curative value upon leprolin, but believe it to possess great diagnostic value. This bacillus has not power of motion. Spore formation has not been demonstrated.

Later Discoveries.

was discovered by a German scientist, Hanson, in 1879, and in the same year the micro-coccus of gonorrhœa by Neisser. (Neisser is also of German birth, probably located at Munich at this time.)

The bacillus typhosus, the germ of typhoid fever, was discovered by Eberth and Koch, of Germany, in 1880.

And in that year (1880) came also the discovery of the germ of pneumonia. Some writers give the credit (or discredit) for causing this disease to the micro-organism observed by General Sternberg* of the United States Army; others to the diplococcus lanceolatus, discovered by †Frænkel, of Berlin, who was professor at Halle. Recent investigation has shown that the diplococcus discovered by Frænkel is probably the sole cause of genuine acute, lobar pneumonia, although other germs, one of which is the "pneumo-bacillus of Friedlander," are said to be sometimes found associated with this form of the disease. Several germs are believed to be capable of causing broncho-pneumonia.

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* Authorities assert that the germ observed by Sternberg and the diplococcus lanceolatus are probably identical.

† Fraenkel associated the germ with pneumonia causation; Sternberg did not.

Koch's Discoveries.

In 1882 the name of Robert Koch* sprang into fame when he made the greatest of his many discoveries—the germ which is the cause of all forms of tuberculosis. This discovery is not only to be considered the greatest of *Koch's* discoveries, but one of the greatest discoveries of the age, as to tuberculosis, in one or another of its forms, is due at least one-sixth of all the deaths which occur yearly in the human family. Had the remedy for this disease, prepared by Koch,* proven a success, he would have immortalized his name in very deed.

In 1884 Koch made another discovery, namely, the comma bacillus of cholera; so-called because of its peculiar shape. (Pasteur discovered the germ of chicken cholera in 1880.) In 1884, also, the germ of diphtheria, called the bacillus diphtheriæ, was discovered by Lœffler, and the bacillus of tetanus, called the bacillus tetani, by Nicolaier.

Progress of Other Scientists.

The bacillus influenzæ, the germ which causes influenza or "la grippe," was discovered in 1892 by Pfeiffer. Loeffler, Nicolaier, Pfeiffer, are all of German nationality. (Lud-

* Koch, born at Klausthal, Germany, in 1843. Led the German expedition which in 1883 went to Egypt and India to investigate cholera. In 1890 announced a cure for tuberculosis, the power of which experience did not at that time demonstrate. Died at Baden-Baden, Germany, May 28, 1910.

* See Supplement, Chap. II, page 207, for recent return to confidence in tuberculin.

wig Pfeiffer, born at Eisenach in 1842, lives at Weimar.)

In 1894 came the discovery of the bacillus pestis, the germ of the Eastern bubonic plague, by Yersin, of France, who was at this time pursuing his scientific investigations in China.

Kitasato, a Japanese, working independently of Yersin, during an epidemic of bubonic plague in Hongkong in 1893-4, discovered the same germ and the result of their researches was proclaimed to the world almost simultaneously.

Koch's Circuit Not Traced.

In 1897, the discovery of the bacillus of yellow fever was reported by Sanarelli, a Spaniard. This germ was not accepted because it failed to comply with certain requisite scientific tests. (Koch's circuit, spoken of in chapter IV, was not proven.) The same is said of the germ found in carcinomatous specimens, and of the germ of small-pox reported by Dr. William T. Councilman, of Harvard College, in the spring of 1904.

It is now definitely known that the *spirochetae pallidae, also called treponema pallidae

*For years Professor Paul Ehrlich,** of the Royal Prussian Institute, had been experimenting with various drugs in order to discover something which should have the power to destroy the parasitic spirochetae within man and the lower animals without injuring the organic

* See Supplement, page 178, for notes on life of Ehrlich.
** Ehrlich was born at Strehlen in the Province of Silesia, March 14, 1854. Died in Berlin, August 20, 1915.

or spironema pallidae, discovered by Hoffman and Schaudinn, of Germany, in 1905, is the

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cells of the body. Not long ago it was the good fortune of Ehrlich to discover a drug (or combination of drugs), which authorities believe possesses the power to destroy the parasite, spirochetae pallidae, the germ of syphilis. This drug is known as arsenobenzol, salvarsen or "606." Ehrlich discovered while pursuing his investigations that the attempt to destroy animal parasites by *small doses* of an injurious drug was unsafe, owing to the fact that the parasites frequently develop a toleration for the drug which they transmit to their offspring. He therefore sought to discover and perfect a drug, the action of which should destroy the parasites by the administration of *a single large dose*, at the same time leaving the subject uninjured. This result he believed he had achieved in his wonderful "606," which is being used with marvelous results in both Europe and America. The active principle of the drug "606" is arsenic. Other parts of the drug are chemical groups used for the purpose of fixing the arsenic to the parasites. The *chemical* name of "606" is "paradiamidodioxy-arsenobenzole dihydrochlorid." In appearance it is a yellowish powder. It rapidly oxydizes on exposure to air and is for this reason preserved in vacuum tubes. It does not dissolve very readily in water, and when thus dissolved is strongly acid. As this acid solution causes great pain, it is administered either as a neutral base or as an alkiline salt. It is given by hypodermic injection either deep into the muscles or into the veins, or subcutaneously. "606" is dissolved in a mortar in one (1) to two (2) c.c. of ordinary solution of sodium hydrate. To this is added acetic acid by the drop method until a fine yellowish suspension is precipitated. This precipitate is then collected in from one (1) to two (2) c.c. of sterile distilled water. To this is added 1-10 normal sodium hydrate, or one per cent acetic acid. The suspension is drawn into a suitable syringe and injected below the shoulder blade underneath the skin. The area used must be *thoroughly cleansed* and *disinfected* in the usual way. Slight pain sometimes follows the subcutaneous injections. Also there may be some elevation of temperature, a rash resembling urticaria, and sometimes a slight swelling about the site of operation is observed on the second or third day. Some fatalities have been reported due to arsenical poisoning.

germ of syphilis. New methods of staining cultures used in 1906-07, by these and other scientists working independently have brought to light the true relationship which this germ (hitherto considered doubtful), bears to the loathsome disease, syphilis, the micro-organism of which has for so many years remained a mystery to the medical profession and to other scientific workers. Authorities in both Europe and the United States are now satisfied as to the authenticity of the spirochetae pallidae (treponema pallidae.)

A great aid in the diagnosis of syphilis, worked out by Wasserman of Berlin, is known as the "Wasserman test."

Many Germs Still Baffle Scientists.

The germs which cause many of our most common communicable diseases still continue to be undiscovered. We are in the dark as to what parasite is responsible for small-pox, scarlet fever, measles, chicken-pox, etc. Rheumatism and *arthritis deformans are believed by some authorities to be germ diseases, but as yet this theory has not been proven, although an antistreptococcic serum is in use in some

Arthritis Deformans.

* Quite recently the streptococcus viridans has been found in the walls of the colon and ileum of patients afflicted with arthritis deformans, and operation (ileo-colostomy) has brought relief in some of the cases reported by investigators in 1915 and 1916.

parts of the United States which has in some instances proven helpful in both of these supposedly incurable diseases.

Serum treatment is, also, being worked out for curative and prophylactic purposes in poliomyelitus cases. Since the terrible epidemic of 1916, a great deal of work along this line has been accomplished with this end in view. A species of streptococci isolated from the brain, spinal cord and spinal fluid of human beings suffering from the disease and from the central nervous system of monkeys in which the disease has been produced by inoculation has led investigators to believe that this form of bacteria is at least associated with the disease.*

SUMMARY OF CHAPTER I.

The earliest days of bacteriology said to be traceable to the time of Caesar, in whose day a Roman writer hinted at the invasion of the human structure by "creatures" invisible to the naked eye and of their power to produce diseases.

The perfection of the single lens. Nationality of the perfector. Discoveries of this scientist during the seventeenth century under the single lens and by means of the compound microscope. The presentation of the results

*See page 223 for vaccine treatment in influenza.

of his researches together with appropriate engravings to the Royal Society of London, England, of which society he was afterward Fellow.

Power to produce the so-called infectious diseases ascribed to micro-organisms by a scientist of Vienna. Theories advanced by this scientist. Non-acceptance of his theories.

The germ theory of disease again advanced about sixty years later and its successful demonstration.

A short account of one of the subjects which caused much discussion during the century and a half between the discoveries of the Hollander and the acceptance of the theory of the scientist of Vienna.

The man who first threw light upon the mystery surrounding this vexed question and the manner in which he carried on his experiments. Work and its results along the same lines by other scientific men of that period.

Errors of some of the early students of bacteriology.

Slow progress in discovering a special germ for each infectious disease.

Men who are considered to have made the most valuable contributions to bacteriology and their discoveries.

CHAPTER II.

THE RELATION OF BACTERIA TO DISEASE—BACTERIA IN PROCESSES OF NATURE.

Revelations of the Microscope.

Mysteries concerning the origin of numerous diseases, which must otherwise have remained mysteries forever, have been made more or less clear since the perfecting of the compound miscroscope. Prior to the revelations made by the use of this instrument, very little was positively known concerning the formation of the various elements of which the machinery of the human structure is made up and by which it is kept in running order. Now scientists are able to trace the human body back to the time when it was but a single cell, from this single cell to watch its growth and development into innumerable single cells, to see the single cells fold into layers, these in their turn to form the groups of cells out of which the various bones and muscles and nerves and tubes and tissues of the body are composed. These groups we call the organs and systems of the body. Each has its own work to perform, and each exists to a certain extent independently of the other. Yet all are so intimately related and connected in their efforts to maintain life and health that when disease comes to one group of cells composing a sys-

Cell Formation.

Organs and Systems.

tem, other groups composing other systems suffer also.

Action of Various Cells.

The group of cells from which the muscular system is made up, by its united action, called into play by nerves, produce our movements. Another group of cells forms the liver and harmonious action of this group is necessary in order that impurities be removed from the blood. Certain fluids which are essential to the welfare of the body are also manufactured by this group. The brain is composed of another group of cells of a different type; from this group thought and intelligence emanate, and from still another group is composed the nerves which convey messages to and fro between the brain and the outer world and so on. When these various groups are all "in tune" then the human body is in a state of health, when they are "out of tune," we speak of the body as in a state of disease. In a state of disease our work is no longer a pleasure to us; our hours of recreation are no longer a joy. Our days are filled with discomfort and our nights are robbed of rest and sweet sleep.

Brain and Nerve Cells.

Definition of Disease.

As nurses, then, let us grasp this thought that "disease is a derangement of the structures or functions of the body," and in order that the human structure remains healthy, there must be harmonious action between separate types or groups of cells. If one group fails to work

harmoniously, then comes a disturbance of the harmony of the other groups, and because of this disturbance there comes disease. For example: If there is trouble in the nervous system, then, too, we find the digestive system is affected, and vice versa. So we may go on through the other systems and find them all more or less dependent one upon another.

Bacteria a Cause of Disease.

The causes of disease are many and varied. One of the most serious causes, as revealed by scientific research, is the invasion of the different organs and systems of the human structure by a species of bacteria; these it has been proven produce many of the so-called infectious diseases. Bacteriological research tends to the belief that certain forms of *molds or fungi and protozoa—are also causes of some of the "infectious diseases." Molds or fungi, are very minute *multicellular* vegetable organisms. Protozoa

* Molds or fungi are held responsible for various skin and hair diseases.

A mold known as the "microsporon furfur" produces a skin disease, "pityriasis," which is found chiefly among persons living under unsanitary conditions.

A disease of the mouth, found in children, and known as thrush, is supposed to be due to the mold "oïdium albicans."

A disease of the scalp, which is called favus, is also attributed to a mold, the "achorion schonleinii."

Ringworm, a disease of the skin, is believed to be caused by still another mold, the "trichophyton tonsurans."

An interesting article on the scalp disease, favus, by Dr. J. E. Lane, of New Haven, Conn., appeared in the Journal of the American Medical Association, October 16, 1915.

are very minute single cell (unicellular), animal organisms, and in this particular are distinguished from all other animal groups. While they are very similar to bacteria, their method of reproduction is different. This method of reproduction has been more fully traced in the study of the disease malaria than in any other of the diseases caused by protozoa. (See Chapter V for malaria.) So much has been said and written on "the relation of bacteria to disease" that many people fail to discriminate between the bacteria which are our friends and those which are our enemies.

Bacteria Explained.

As pupils in the study of bacteriology we learn that the term bacteria is applied by scientists to the large group of minute single cell vegetable micro-organisms or plants, commonly called "germs" or "microbes." This name was first given to them about the year 1869, after *Hoffman had demonstrated that these tiny mysteries occupied a class by themselves, quite distinct from yeast plants and molds with which they had been confused in earlier days of bacteriological research. For years scientists had been unable to decide as to whether bacteria were members of the plant family, or whether they were the

*Hoffman was a German botanist. Born at Roedelsheim, 1819; died at Giessen, 1891.

offspring of animal life, for the reason that they were found to possess characteristics of both families or kingdoms. When it was discovered under the microscope that some of the bacteria are spore-forming, their classification as members of the plant or vegetable kingdom was determined. Absence of chlorophyl, the name given to the green coloring matter of plants, caused doubt to arise in the minds of many; chlorophyl is the property in plant life, which enables them to cause decomposition of carbon dioxide and ammonia and to consume as food their products. Bacteria, lacking this property, feed upon the same forms of food as the higher animals consume.

Animals or Plants.

Saprophytic Bacteria.

All forms of bacteria may be divided into two great classes in order to simplify for study. These two classes are called the saprophytes, and the parasites. The saprophytes, which are the friends of all animal life, are many times more numerous than the parasites. Of the numberless species of bacteria only about forty (40) are *known to cause disease in man.* Parasites are enemies to animal life; they are the so-called "disease germs" or "microbes"; they exist only at the expense of other living bodies. They invade various parts of the living body and under favorable conditions they weaken and sometimes destroy the parts they invade.

Parasitic Bacteria Our Foes.

They take away from us substances on which our health is dependent, and deposit in their place toxins (or poisons) which often completely destroy life. Because of their power to produce pathological changes in animal bodies, parasitic bacteria are also called pathogenic bacteria.

Good Bacteria.

Saprophytic bacteria not only are our friends, but they are of such benefit to mankind that we could not live without them. They feed upon dead organic matter, and by their activities decomposition, fermentation and putrefaction are produced. Nourishment necessary to the sustenance of vegetable life is derived from carbonic acid gas, ammonia and water, which are all produced by the action of saprophytic bacteria on dead animals and vegetables. Vegetable and plant life would cease to exist if the carbon and nitrogen to which they owe their growth and development could not be obtained from this source. Animal life is sustained by the oxygen thrown off by trees and plants and to a certain extent by the food obtained from the vegetable world; therefore, the work of the saprophytes is necessary to the existence of all forms of life.

Bacteria in Natural Processes.

With regard to the work of saprophytes as our friends in the processes of Nature, let us look a little farther into this phase as explained to us by scientists. Let us see why it is that

they play so important a part in these processes, and how it is that they are so completely interwoven with the vital powers of nature, that life in all its forms would vanish from the earth should their activities cease.

Decay of Trees and Plants.

When as children we explored the woods and perched ourselves upon fallen tree trunks and saw them dropping into decay, how many of us now studying bacteria in regard to their connection with our work as nurses ever associated the process of decay with the activities of germs? Today we are taught that bacteria play an important part in this process after the hard, woody substance of the tree has been softened and prepared for their work by molds. Then, after the tree has been attacked by bacteria, it drops to pieces as a yellowish brown deposit, to mix with dead leaves and sink into the soil as a fertilizer to promote the growth of healthy plants and trees that inhabit the forest.

Decay of Animals.

The same thing happens in decay of dead plants and animals. In decomposition of animals saprophytes play a still more important part, as it is by their agency alone that the work on every part of such bodies is accomplished and the preparation made for mixing with the soil and the atmosphere. Whatever of the decayed substance of tree and plant and animal is not of use as a fertilizer is disseminated in

the form of gases to be taken up by the air, to be returned to the elements from which it came, again to be used in the formation of something else in the various processes of Nature. So plant and vegetable and animal life is renewed and sustained in a great measure through the fertilization of the soil by decomposition of dead plants and vegetables and animals, and by the gases they disseminate, none of which would come to pass without the activities of bacteria. As a notable and probably the only exception to the knowledge we have gained that saprophytes are our friends and benefactors is that they produce ptomains.

Ptomains.

Ptomains are certain poisons which saprophytic bacteria produce in their endeavor to destroy dead organic matter. If such food-stuffs as meat, oysters, fish, ice-cream, etc., are not kept on ice, in properly constructed refrigerators, or otherwise preserved or protected, saprophytes will attack them. Should we unfortunately use these food stuffs, after they are thus attacked, a disease known as ptomain-poisoning results. Death has followed severe cases of ptomain-poisoning.

Where Oxygen is Obtained.

We inhale from the atmosphere oxygen, which is absolutely necessary for the subsistence of animal life, and which is thrown off for our use from growing plants and trees and other forms of vegetable life. We exhale carbonic

acid gas, or "carbon dioxide," which, together with the influences of the sun and the rain, is necessary for the growth and sustenance of trees and plants and vegetables. This is one way, among others, in which the animal kingdom is necessary to the vegetable kingdom and vice versa, the plant and vegetable world giving off oxygen for use of the animal world, and the animal world in its turn supplying the plant and vegetable world with carbon dioxide in a ceaseless round. All other foods used to sustain animal and plant life are so arranged by the processes of Nature as to be used again and again in a continuous circle, first by plants and then by animals, and then over again by plants, the circle to endure so long as the sun shines and the rain falls to promote its continuance. Many of these processes require much thought in order to understand the intricate workings of Nature. Those who undertake the study in earnest find it of special interest. Not the least interesting phase is the way in which nitrogenous foods, so necessary to animal life, take their place in the continuous circle, and through the assistance of bacteria are prepared to return to take part in the maintenance of plant and vegetable life.

Nature in Food Supply.

Bacteria which assist in the sprouting of seeds and in other processes of Nature in farm and garden and dairy, form an interesting

study, also. To those who desire to be nurses, however, how to combat bacteria in disease is of most importance.

SUMMARY OF CHAPTER II.

Mysteries with regard to diseases revealed by the microscope.

Cell formation and the formation of the organs and systems.

Health of the various organs and systems of the body dependent one upon another.

Functions of some of the groups of cells.

Derangement of the structure and its functions the cause of diseases.

Bacteria as friends and as enemies.

Application of the term bacteria.

Length of time the term has been in use and the scientist who first distinguished the group from yeasts and molds. His nationality.

Difference in size of the saprophytic and parasitic families.

What we understand by the term pathogenic bacteria.

Saprophytic bacteria and the benefits derived from them by the animal and the vegetable kingdoms. Their formation of ptomains.

CHAPTER III.

DESCRIPTION OF THE MOST IMPORTANT BACTERIA, METHODS OF MULTIPLICATION, ETC.

Morphology Defined.

MORPHOLOGY is that branch of science which treats of the classification of bacteria with regard to their shape, outline, structure and their methods of grouping. Placed in broth, gelatin, blood-serum, bouillon or other suitable substance they are cultivated, and much useful information has been gained with regard to the habits, etc., of these tiny specimens of vegetable life. The material in which bacteria are grown or cultivated is called *"culture media."

It has been found by studying them under the microscope, that all bacteria of any importance are either "sphere," "rod," or "spiral" shaped, and so they are divided into these three classes.

Micro-cocci.

Spheres.

The spherical may be perfectly round like a ball or marble, or they may be oval or egg-like; they vary in size and many are imperfect in shape. The name given to all bacteria of this formation is "cocci" or "micrococci."

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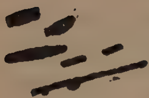
* Certain formulae for preparing "culture media" are found in the equipment of all up-to-date laboratories. These may be studied only in the laboratory, as they require to be followed very closely and very accurately in order to obtain results.

Bacilli.



Rods.

The rod-shaped may be long or short, square or rounded at the ends, thick or thin, but all bear the common name of "bacilli." The largest number of disease germs are of this class.

Spirilla.

Spirals.

The spiral-shaped somewhat resemble the twisted part of a corkscrew, and whether they have few or many curves, whether loosely or tightly twisted, the one name, "spirilla," covers all of this variety.

Modifications or subdivisions of the cocci have also been determined by watching their manner of forming into groups as seen in growing cultures.

Staphylococci.

Staphylococci.

Staphylococci is the term used to describe those which group in masses like grape-clusters.

Streptococci.

Streptococci.

Streptococci, to describe those with method of grouping into chain-like sections.

Diplococci.

Diplococci.

Other forms of the micrococci are found to group in pairs, and to describe these the term diplococci is used.

Tetrads.

Tetrads.

Those which form into groups of four are called tetrads, or tetracocci.

Sarcinae.

Sarcinae.

Still another form is seen to make up groups of eight and sixteen, and to describe these we use the term sarcinæ.

There are two main subdivisions of the bacilli, namely; bacilli which are spore-forming, and bacilli which are non-spore-forming. By the term spores we mean seeds or eggs of the bacilli. The bacilli alone produce spores.

Oxygen.

All forms of bacteria are dependent upon certain conditions for their development; these conditions are a certain temperature and food, moisture, proper soil, and *in some instances oxygen as found in the air.*

Aërobes.

Anaërobes.

Facultative Bacteria.

Bacteria that require oxygen, and that *cannot live without it,* are given the name of *aërobes.* Those that do not require oxygen, and to which class it *causes death,* are called *anaërobes.* Bacteria that have the faculty of living either in or out of the presence of oxygen are called facultative bacteria. Those *most active* in the presence of oxygen, *yet able to live without it,* are spoken of as facultative aërobes. Those thriving best without the presence of oxygen, *yet able to live with it,* are called facultative anaërobes. The bacillus of tuberculosis and of diphtheria are aërobes. The bacillus of tetanus is an anaërobe. So also is the bacillus of malignant edema. The anthrax bacillus is a falculative anaërobe.

Food.

Pathogenic bacteria require organic matter to feed upon. Vegetable or animal matter, fluid or solid, fresh or decayed, all kinds are adapted to their use as food, but the blood and juices of the animal body tissues are specially favorable material for their growth and development.

Temperature.

The temperature of the human body, viz., 98.6° F., is the most favorable for the multiplication of pathogenic bacteria, although they will also multiply quite rapidly in a lower temperature; 70° F. (ordinary summer heat) is sufficiently high. Below 70° F. their growth is slower and has been found to cease at 60° F. A temperature of 110° F. is believed by many to prevent their growth.

Moisture.

In order that bacteria may grow and reproduce they must have moisture.

Size of Bacteria.

Size of bacteria is a part of their description difficult to determine. So tiny are they that it is only under the highest power of the microscope that scientists are able to study them at all. One of the largest of the bacilli is said to be about 1-12,000 of an inch in length, and 1-50,000 of an inch in thickness. We are told that it would take six thousand billions of the average sized bacilli to weigh one grain, and that fifteen hundred of the largest bacilli if placed end to end would not reach across a small pin head. Bacteria are single cell

plants (unicellular), but this single cell is capable of producing innumerable other single cells under favorable circumstances. Some forms of bacteria move about quickly, through flagella, an appendage which is like the very fine hairs of an eye-lash in appearance and by means of which they are made to resemble a form of animal or insect life. Other flagellated bacteria are very slow in their movements. Still others without flagella are without movement.

Power of Reproduction and Motion.

Bacteria with Flagella.

Bacteria with flagella.

Weigert's Discovery.

Weigert* in the year 1877 discovered that micro-organisms can be colored or †stained by the use of aniline dyes, so as to be distinguished

*Professor Carl Weigert, anatomist at Frankfort, Germany.

† In *ordinary* staining processes a particle or drop of the specimen to be examined (pus, sputum, blood-serum, etc.) is placed on a sterile cover glass or slide, a drop of sterile water is added and the two are thoroughly mixed and thinly spread over the face of the glass by means of a platinum rod, which must have been made sterile by passing through the flame of an alcohol or other spirit lamp. The specimen is allowed to dry in the air and is also passed several times through a flame, in order both to *sterilize* the specimen and to make it *stick* to the cover glass or slide. It is then covered or "flooded" with the staining solution and allowed to stand for twenty to thirty seconds, after which the staining solution is poured off, the cover glass or slide is washed in sterile water, dried in the air and sterilized again by passing it through a flame. The specimen is now ready for microscopic examination.

The platinum rods must always be sterilized before

from the media in which they are cultivated. Up to that time great difficulties stood in the way of their successful study, because of their transparency as well as their minuteness. Since Weigert's discovery that they can be colored, many of the peculiarities by which their varieties are determined have been pointed out. New methods of coloring or staining bacteria were brought into use in 1906-07 by Hoffmann and Schaudinn, of Germany, *Gram, and others. Aniline dyes used for coloring or staining bacteria in ordinary microscopic work, are solutions of gentian-violet, fuchsin and methylene blue. Some bacteria which will not take on one color will very readily adopt another color. This peculiarity has great

Difficulties Surmounted Through Staining.

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and after using. Sterilize before using to mix and spread the specimen in order to kill any germs that may be on it, so as not to mix them with the culture, and sterilize afterward, before laying it down, so as to avoid danger of spreading or scattering the germs in the culture specimen you have been staining.

* Gram has perfected a method of staining bacteria which are especially difficult to identify. The material containing the bacteria (pus, blood, sputum, etc.) is spread on the cover glass or slide in the ordinary manner, and is stained with a gentian-violet solution by the aid of slight heat; the stain is poured off and the cover glass is treated with iodin solution and washed first with absolute alcohol and afterward with water.

Gram's method is a very valuable one, as through its use certain of the bacteria have been found to lose their violet color after the alcohol bath. Upon others the alcohol treatment has no effect, as they are still found to be violet in color. Gram's method is used in identifying the bacteria causing gonorrhœa, meningitis, etc. Those germs which retain their violet color after the Gram test are called "Gram positive." Those which lose their violet color are called "Gram negative."

diagnostic value; many bacteria being recognized by their staining a certain color or by their failure to do so. The bacillus of tuberculosis is very difficult to stain. A solution of carbolic acid and fuchsin (red) is necessary in order to stain this bacillus.

The Healthy Body.

We have said that one condition necessary to the growth and development of bacteria is *proper soil.* A perfectly healthy body with normal resistive power is not favorable soil for the development of disease germs. In such a body certain cells exist which are foes to these germs; they have the power either to absorb or destroy disease-producing bacteria. Some of these cells are found in the white corpuscles of the blood, the leucocytes, and are called phagocytes; the process of destruction or absorption is known as phagocytosis. The name phagocytes (from the Gk. phago "I eat") was given to these cells by the man who discovered their province, the scientist, *Elié Metchnikoff, a Russian, one of the most distinguished scientists of the present age. He carried on the work at Pasteur Institute, Paris, as successor to Pasteur, until his death in 1916. While scientists differ as to the method of warfare as waged

Phagocytes.

Function of Phagocytes

Metchnikoff the Russian.

* Metchnikoff was born in the government of Kharkoff in 1845. Was professor at Odessa in 1870. Of his dramatic death the *World's Work* says: "Professor Metchnikoff came to his laboratory on July 13, 1916. He did not attempt to hide his uneasiness at the weakness of his heart. He surprised his students, however, by saying as he put on his things to go home: 'Tomorrow is the 14th, isn't it? So we won't work. I am afraid that this will be my last day here. I cannot last two days. I shall die tomorrow.' He died, in fact, on the 15th, and his pathetic farewell made a deep impression even on the pathology students."

between the cells of the body, termed phagocytes, and the germs of disease, most of them agree that the healthy body has the power to overcome and exterminate such foes by their means. Scientists who are not associated with the school of Metchnikoff, teach us that there are properties contained in the serum of the blood known as opsonins, discovered in 1903 by Sir Almoth E. Wright, of England, which assist the phagocytes very materially in their work. They prepare the pathogenic bacteria in some unexplained manner, making them more readily digested and absorbed and then attract them toward the phagocytes.

Wright of England.

The body which is not healthy, and in which normal resistive power is absent, on the other hand is not able successfully to fight disease-producing germs which invade it at one point or another, they overcome weakened resistive forces, increase and multiply within the body, and we become victims of the disease the special form of bacteria present produces.

The Unhealthy Body.

There are two methods of multiplication in the bacterial world—fission and spore formation.

The method by which micro-cocci and spirilla multiply is termed fission; fission in common everyday language means simply division. They rapidly separate or divide into a number of sections, each of which soon leaves the parent cell, and in turn divides into other

Fission.

sections or parts. The micro-cocci before fission takes place elongate or lengthen out, they then divide in the center, each half again divides and these new sections also repeat the process again, and again. In many instances they divide at right angles to the first division and again at right angles, forming in this manner the groups of two, four, eight and sixteen, which have been mentioned as the "diplococci" "tetrads" and "sarcinæ". Those which upon division do not immediately become detached one from the other, but which form into chain-like sections have also been described as bearing the name of "streptococci." Others again that remain grouped in clusters, we have learned are called the "staphylo-cocci." The process of division and subdivision is kept up as long as the germs have proper soil to exist upon, provided, also, the food, temperature, air and moisture are such as they require.

Method of Division and Subdivision.

Drying.

In a few forms of bacteria drying kills. The spirilla of Cholera is one of these. In the larger number drying only prevents growth until favorable conditions arise.

Bacilli Method of Multiplication.

Bacilli multiply in much the same way and under conditions similar to those required by the micro-cocci and spirilla. This is especially true of the bacilli which are non-spore-forming.

Spore-Forming Bacilli.

With regard to the spore-forming bacilli, when they can no longer obtain sufficient or

proper food or surroundings, they shrivel or dry up and appear to be dead. They may keep up this semblance for months, but let conditions once more become favorable for their development and we soon find they not only are not *dead*, but are *not even sleeping* merely *resting*. Place them in suitable culture media, for instance, and immediately they begin to germinate and produce innumerable micro-organisms of the same variety as those from which they sprang. They do not reproduce other spores at once, but *never fail* to reproduce that characteristic variety of bacillus *which is spore-forming*. Fortunately for the human family the number of spore-forming bacteria is small, and not one is known to be instrumental in producing a pestilential, epidemic disease.

Protoplasm Defined.

Spore Formation.

There are certain changes which take place in the bacilli when the process of seed or spore development is about to begin. Spores, or seeds, are made up of tiny particles of the protoplasm or active, life-giving substance of which bacilli are composed. They form sometimes at one end of the rod, sometimes at the other end, and again they may form in the center of the rod, often making the center much larger in diameter than the rest of the rod, thus giving to it a peculiar spindle shape. They at first appear to be just tiny, glistening spots, or dots in the protoplasm,

or life-giving matter of the parent bacillus, but very soon they begin to divide off and are easily distinguished under the microscope as tiny seeds or eggs which scientists call "spores." They rapidly increase in size and break through the framework of the bacillus, the non-essential part of which usually dies and the seeds or spores are left behind in a protecting cover or capsule. This cover or capsule is such as enables spores to resist influences that would very quickly destroy other forms of bacteria. The power possessed by spores to resist heat and drying is found to be almost incredible. Bacteriologists assert that some

Resistive Power of Spores.

Spore-forming bacillus.

forms of spores live on after they have been exposed for a brief period to a temperature of 360° F. Other forms have been treated to a *bath of boiling* water for a longer period, and yet both have come through these processes *alive* and have *again germinated.*

While the parent bacillus, as a rule, is supposed to die during spore formation, because the spores use up the protoplasm of the parent cell for their own sustenance, this is believed not to be true in every instance. The functions of the parent cell are said sometimes to go on in the usual way during the process of spore-forma-

Spore-Forming Bacilli.

tion, sufficient of its protoplasm being retained to sustain life and again to renew its activities after the spores have broken through its walls.

SUMMARY OF CHAPTER III.

Classification with regard to shape, outline, etc.

Definition of various names descriptive of bacteria.

Methods of grouping as seen in growing cultures.

Terms used to designate methods of grouping.

Bacteria which form spores and those which do not.

Development of bacteria dependent upon certain conditions.

Why it is difficult to determine dimensions of bacteria.

Discovery of Weigert and others.

Power of phagocytes and opsonins.

The discoverers of phagocytes and opsonins.

Why bacteria sometimes conquer the phagocytes.

Methods whereby bacteria multiply.

Process of spore-formation.

Definition of protoplasm.

Wonderful resistive power of spores.

Parent bacillus after the process of spore-formation.

CHAPTER IV.

DISEASES CAUSED BY BACTERIAL INVASION. HOW BACTERIA GAIN AN ENTRANCE TO THE SYSTEM.

Parkes, in his "Manual of Hygiene and Public Health," gives the following table of diseases due to the invasion of the human structure by bacteria. He divides these diseases into five classes, viz.:

CLASS I.

Smallpox,	Influenza,
Scarlet Fever,	Relapsing Fever,
Measles,	Diphtheria,
Mumps,	Erysipelas,
Chicken-pox,	Typhus,
Whooping Cough,	Epidemic Pneumonia.

CLASS II.

Yellow Fever,	Dysentery,
Cholera,	Diarrhœa.
Enteric (Typhoid) Fever,	

CLASS III.

Anthrax or Malignant Pustule,	Vaccinia,
Foot and Mouth Disease,	Ophthalmia,
Leprosy,	Syphilis,
Glanders,	Gonorrhœa,
Rabies,	Tetanus.

CLASS IV.

Erysipelas,	Hospital Gangrene,
Septicæmia,	Puerperal Fever.

CLASS V.

Tuberculosis, including Lupus and Scrofula.

I.—Diseases placed in class one are designated as *air-borne,* in other words, diseases

which may be carried and communicated by floating dust.

II.—It is claimed that diseases placed in class two may be carried and communicated by floating dust or taken into the system in water. The *"air or water borne" diseases,* so-called.

Inoculation

III.—*Inoculation as a rule, is the means of communication of diseases mentioned in class three.

Lesion.

IV.—A surface lesion is said to be necessary for the communication of diseases in class four. When this lesion is present the disease is communicable by direct inoculation or may be transmitted through the air. (By "lesion" we mean a wound, hurt, or other local alteration of tissue from a higher to a lower condition.)

V.—In class five a surface lesion is not necessary and the disease is communicable either by direct inoculation or through the air.

It must be borne in mind, however, that authorities differ as to the mode of entrance of some of the bacteria and that theories change as new light is thrown on the subject. The science of bacteriology is still rapidly progressing.

Authorities Differ.

The alimentary canal, the respiratory tract, the genital tract, the mucous membranes,

* By inoculation we mean the introduction of a specific virus into the system.

Channels of Entrance.

wounds and the skin, all form channels whereby infection is conveyed to the various parts of the body which are seats of attack for pathogenic bacteria.

Period of Incubation.

An incubation period, which varies in duration, is common to all forms of disease caused by the invasion of bacteria. During the incubation period there are no symptoms of the disease. The germs have gained admission to the body by one or other channel of entrance and a war is being waged between the invaders and the antagonistic cells of the body, some of which have been spoken of as phagocytes and opsonins.

Period of Invasion.

Under favorable circumstances the invaders do no harm, they are destroyed by their foes and are thrown off from the body in the excretions. If the powers of resistance are weakened in any way, by the presence of any other disease, for instance, the influence of the antagonistic cells is lost and the period of incubation ends in another period, (invasion), wherein the power of the invading bacteria is made manifest and symptoms arise followed by more or less serious results.

In each specific disease the infection is thrown off from that part of the body which is the *seat of the invasion.*

Why Multiplication Ceases.

During the course of a communicable or specific disease there comes a time when there is no longer any suitable nourishment for the

growth and development of the micro-organisms and then the disease is starved out. Sometimes the action of the germs upon the cells of the body produces a condition which is poisonous to the germs themselves and thus they are destroyed by the products of their own *vital* activities. In either case the tissues are left in a state of immunity from that particular disease for a longer or shorter period, sometimes for life. We are told of three forms of immunity.

Immunity.

I.—Natural immunity, which is the natural and constant resistance of the antagonistic cells or phogocytes to the development within the body of pathogenic bacteria.

Natural Immunity.

II.—Acquired immunity, which is that immunity given to the body, or which the body gains, by a single attack of a certain communicable disease.

Acquired Immunity.

III.—Artificial immuity, which is that immunity given to, or gained by the body, through the use of antitoxins.

Artificial Immunity.

NATURAL IMMUNITY.

Let us look a little farther into the subject of natural immunity and the part played therein by several allies to the phagocytes.

First, let us consider the protection afforded the healthy human body by its inner and outer surfaces.

We have said in another chapter that bacteria exist everywhere. Our skin, finger-nails, hair follicles, etc., all harbor them. Their numbers are limited only by the cleanliness of the individual and even on the surface of the bodies of the most cleanly the existence of some pathogenic bacteria is a normal condition.

Cleanliness.

The Skin.

It has long been an open question whether or not micro-organisms found upon the skin can gain admission, find their harmful camping ground and bring about diseases unless the skin has a broken surface, or is in some way injured. In some instances it has been proven that injury or abrasion is not always necessary in order that germs of disease penetrate the skin and do us harm. Entrance through an absolutely unbroken skin is a rare occurrence, however, and then it is believed that the portal of entry is either through the openings of the sweat glands or the hair follicles. When invasion takes place, we find as a result that such troubles as pustules, boils, carbuncles, etc., caused by pyogenic (pus-forming) bacteria arise. As a rule, while the sebaceous glands, which are the appendages of the hair follicles, do not secrete germicides, the perspiration is of an acid nature, believed to be slightly germicidal and it also contains salts which cause it to be an enemy not easily overcome by certain

Its Fortifications.

forms of disease germs. The unbroken skin does not absorb bacterial toxins.

Subcutaneous Connective Tissue.

Subcutaneous connective tissue, as a rule, is a formidable barrier to the entrance of pathogenic or disease germs even after they penetrate the skin, although there are exceptions to this rule, also, as there are exceptions to all general rules.

Mucous Membranes.

The mucous membranes by reason of their moist condition favor the growth and development of a number of bacteria; yet, by a certain mechanical process, these are constantly excreted and removed without causing the perfectly healthy any harmful result.

The Conjunctiva.

Certain conditions of the conjunctiva favor the entrance of harmful germs, yet the constant mechanical action of the eyebrows, the eyelids, the eyelashes, the tear irrigation of the surface of the conjunctiva and the germicidal power of the tear salts; the rapidity with which the conjunctival epithelium is found to bring about the process of repair, all of these agents tend to protect this surface from infection, healthful conditions being equal.

The Nose.

While it is true that the cavity of the nose is a common ground for the camping of such germs as the staphylococci, the streptococci, the bacillus of diphtheria, etc., they are for the most part held in abeyance owing to the filtering action of the small hairs on the inner sur-

face of the nose which are kept in motion as we breath in the bacteria-laden air. The curves in the nasal cavity also catch dust laden with bacteria and deposit it in the moist surface of its walls where it is imbedded in mucous and thrown off by the nose blowing process, if our bodies are in a normal condition.

The Mouth.

Thirty or more different micro-organisms are said to be normally present in the mouth; among these are found some that are pathogenic. The diplococcus pneumonia and the diphtheria bacillus are among the number. Yet in a condition of healthfulness these are expelled through the action of the saliva and the desquamating of the epidermis due to the process of mastication. While saliva is not a germicide, we are taught that it exerts some influence over disease-producing germs whereby their growth and virulence are lessened.

The Lungs.

In the passage of disease germs to the vital portions of the lungs, we have seen that the surfaces of the nose and mouth play an important part in reducing their harmfulness. The surfaces of the walls of the bronchi also serve as an impediment to their progress. Here they are imbedded in a coating of mucous to be, as a general rule, coughed up and expectorated unless the system is in a condition to favor the development of bronchitis, pneu-

monia, tuberculosis, etc. *A neglected cold* often induces such conditions.

The Stomach.

The hydrochloric acid which the gastric juice contains is said to be able to deal a death-blow to the germs of typhoid fever, tuberculosis, cholera, dysentery, and some other pathogenic micro-organisms, when they reach the stomach in food or water. The gastric juice is believed by some authorities to render many disease-producing germs harmless by digesting their poisons. As nurses, we have learned by experience that such germs are not by any means always destroyed by the juices which the surface of the stomach secretes and expels. They reach the intestines when such powers of resistance are weakened through our failure to take care of our health, and typhoid fever, cholera, dysentery, etc., flourish because of our negligence. Bacteria and their toxins are often thrown off from the stomach in the process of vomiting.

The Intestines.

The protective power possessed by the secretions of the intestinal surfaces is limited. Bile is slightly germicidal; it also neutralizes some of the toxins. The pancreatic juice has the power to destroy some of the products of pathogenic bacteria. In a state of health, harmful germs are eliminated in fecal matter.

The protection against disease germs afforded the healthy human body by the surface of the

genito-urinary tract, is due to the acids thrown off from the vaginal walls and the irrigation due to voiding of urine.

Phagocytosis.

The discovery of the province of the phagocytes we have already stated is due to the researches of Metchnikoff of the Pasteur Institute, Paris. The phagocytes are in reality the leucocytes or white corpuscles of the blood. Metchnikoff was the first to discover and demonstrate and announce that these cells of the body have the power not only to devour pathogenic bacteria, but also to destroy and digest them after they are devoured. Metchnikoff also taught that the leucocytes have the power to excrete germicidal substances into the plasma and serum of the blood giving to the serum greater power as a germicide than it is known to possess normally. Metchnikoff also believed that the phagocytes, the name he had given to the leucocytes, may also absorb the poisons or toxins of pathogenic bacteria, and in some manner cause these to be harmless.

Other theories concerning substances said to be contained in the healthy human body, which by their action render us immune or protected from the inroads of disease germs, present difficulties too great for students just beginning to look into the science of bacteriology, and are really of more benefit to physicians than to nurses. In our work, we

only need such knowledge as will serve to help us to keep healthy ourselves and to aid us in our profession as care-takers of the sick.

Acquired Immunity.

With regard to acquired immunity which comes to us as a result of one attack of a communicable disease. It has already been stated that in some instances our recovery is due to the death from starvation of the germs of that disease, for the reason that they have consumed all the suitable nourishment that existed within us. We not only recover, but are left protected (immune), for a time from a recurrence of that particular disease. Or, instead of death arising from starvation, sometimes the germs have over-reached themselves in their work of destruction and have produced within us a substance which proves to be a source of death to themselves and of protection or immunity to us. In some diseases we are immune for years, sometimes for life. In other diseases the state of being immune may be only short lived. Lasting immunity is usually afforded by one attack of such diseases as smallpox, scarlet fever, measles, typhoid fever or plague. While in influenza, pneumonia, diphtheria, cholera, etc., the protection afforded us by one attack is often very brief, and seems rather to predispose to other attacks.

Artificial Immunity.

In artificial immunity, Metchnikoff taught that when antitoxins are injected into a subject,

they stimulate the phagocytes into greater activity and also lend to them greater power for destruction and absorption of pathogenic bacteria and of their toxins. The substance opsonin, is said by some authorities to act as an ally to the phagocytes by rendering them easier of digestion and of absorption. While

Opsonins.

opsonin is always normally present in the blood serum, it is now believed by many scientists to be increased in both acquired and artificial immunity and is of great assistance to the action of the phagocytes, not only by rendering bacteria easier to destroy, but by attracting them toward their destroyers, the phagocytes.

The Opsonic Theory.

The following article, by L. B. Newell, M. D., copied from the May (1907) number of the *North Carolina Medical Journal,* gives a very clear explanation of the "Opsonic Theory."

"The immortal Pasteur realizing the immensity of the subject of the causation of disease by germs and seeing the effect of the use of vaccine upon smallpox, uttered the prophecy that the day would come when we would treat all bacterial disease by vaccination.

Nature Is Jealous.

Nature takes ample care that we find out her secrets only after an infinity of work, yet as the years go by we begin to realize more and

more how prophetic were the words of Pasteur. Step by step biologists, bacteriologists, pathologists and therapeutists have been drawing nearer the goal, each investigator profiting by the errors of his predecessors—each coming a step nearer the truth.

Pasteur the Prophet.

Years ago Metchnikoff promulgated his theory of Phagocytosis. Since his time it has been known that when bacteria enter the tissues of the body the system at once endeavors to combat their invasion by sending vast numbers of white blood cells to meet the enemy. To that mysterious power of attraction which exists between the invading bacteria and the leucocytes, or phagocytes, we have applied the term chemiotaxis. The phagocytes have the power under certain circumstances of picking up the microbes, ingesting them and killing them. Metchnikoff, believing that the leucocytes were the only active elements in the process of phagocytosis, held that the fluid portion of the blood was merely an indifferent medium. Others taking up the work found that the serum is far from being inactive or indifferent. They found that the invading bacteria are in many cases victorious and overcome the defensive leucocytes. And this led to the question why either the bacteria on the one hand or the white blood corpuscles on the other hand are not always victorious.

Chemiotaxis.

Attempts to answer this have given rise to many theories and much theorizing. Over in one of the great English* hospitals there is a man, Sir A. E. Wright, who has asked this question and has answered it with such finality that the scientific world has almost accepted it as proved. He has found that there are in the blood serum or plasma certain substances which act upon bacteria in such a way as to prepare them to be ingested and destroyed by the leucocytes. Without this substance or these substances the leucocytes are powerless. To this power, substance or property of the blood has been applied the term Opsonic, derived from the Greek word Opsono, meaning "I prepare food for" or "I prepare for dinner." For our purposes it matters little what the properties and characteristics of opsonins are. Apparently there is a different opsonin in the blood for each form of bacteria. It is a fact readily observed that an individual often succumbs to one infection more readily than to another; likewise the same individual at one time seems immune to a certain bacterial disease, at another he quickly falls a victim to the same affection. According to our opsonic theory we would explain these facts by the varying degree of opsonic power of the blood. Instead

Wright's Answer Final.

Derivation of Opsonin.

* St. Mary's Hospital, Paddington District, London, England, where Wright established a department of scientific research in 1905.

of saying that the infection is more virulent or that his vital resistance has been reduced we say the opsonic index is low.

Variation in Opsonic Content of the Blood.

It is claimed by the discoverer that there actually is a variation at different times in the opsonic content of the blood. In other words the blood of an individual will be stronger or weaker in opsonic power, or the blood of the same individual will be at different times stronger or weaker in opsonic power as regards each disease germ.

Power Contained in Serum.

That the leucocytes are powerless to fulfill their function as phagocytes without the help of opsonins is according to the advocates of the theory entirely established. Without describing in detail the methods by which this is proved it is sufficient to say that the leucocytes isolated by appropriate methods and mixed with living germs in a liquid saline medium do not attack bacteria; but if blood serum be added to the mixture of leucocytes and bacteria the phagocytic activity begins at once. This undoubtedly proves that the serum contains some substance which enables the leucocytes to attack and destroy the micro-organisms.

Wright has originated a very ingenious method of determining the opsonic power of the blood by comparing the opsonic potency of the blood of the individual under observation

with that of the mixed blood of a number of normal persons. The degree of opsonic power as determined by this method has been termed the opsonic index.

Suppose a patient is suffering with an infectious disease like tuberculosis, acne, or ulcerative endocarditis. In such conditions why are the leucocytes unable to prevail in their battle with the invading germs? It is because the opsonic index is below normal or those substances which enable the leucocytes to fight the germs are diminished. The problem therefore naturally presents itself: increase the opsonins, raise the opsonic index to normal or above normal and the defenders will prevail!

For obvious reasons any description of laboratory processes in a paper of this kind is entirely out of place, but the practical application of this theory is about as follows:

Test for Opsonic Index.

An individual is about to undergo treatment for infection by a certain germ. His blood is tested for its opsonic index, which indicates whether or not his vital resisting powers are above or below normal. If below normal he is given a hypodermic injection of a specially prepared culture of the germ which caused his disease—the micro-organisms having previously been rendered harmless by heat. As a result the opsonic power is at first diminished, but this is invariably followed by a positive

increase; this is repeated at suitable intervals as indicated by frequent blood examinations, the object being to keep the blood serum in a condition to prepare the bacteria for destruction by the white blood cells, that is, in as high a state of opsonic power as possible.

Practical Application.

This principle is being put to very successful practical application in staphylococcic infection of the skin such as acne and boils; in tuberculosis of the joints, glands and even in consumption; empyema due to presence of the pneumococcus, ulcerative endocarditis caused by the streptococcus and in various other forms of specific bacterial diseases. It is not applicable except to those diseases of which the specific causative germ is known.

In other words opsonin treatment is an attempt to increase the power of resistance of the body to attacks by pathogenic organisms. The results of bacterial invasion are in part, impairment of digestion and assimilative function, normal metabolism is interfered with, so that tissue waste must be repaired, nutrition fostered and strength conserved."

Antitoxins.

ANTITOXINS are antidotes to bacterial poisons. These substances are obtained by injecting into the body of one of the lower animals, found subject to the disease, poisons produced by pathogenic bacteria while develop-

ing in gelatin, broth, bouillon or other culture media. After the bacteria have remained in the culture media for a stated period their poison *permeates* it. Some of the bouillon is then taken and injected into the chosen animal, with a special syringe, in very small doses at first, which are gradually increased until the animal ceases to exhibit any symptoms of the disease, the poison of which has been used for the injections. Then he is said to be immune or protected from that particular disease. (Horses, goats, guinea pigs, rabbits, etc., are all experimented upon. The horse is preferred for the development of diphtheria antitoxin.) Some of the blood of this immunized animal is then procured and allowed to coagulate and the serum or fluid part is injected into other animals or into members of the human family, in the same way in which it was used in the first instance, until they too become immune from that specific disease for a longer or shorter period.

Animals Experimented Upon.

Protection.

Testing.

Before using the blood serum of an immunized animal on the human subject it is tested in another of the lower animals for the purpose of ascertaining its protecting power. If it stands the test, it is put up in small tubes or containers sterilized and tightly sealed until required for use. Each of these tubes or containers is made in the form of a special syringe, which contains 500 to 1,000 units. A special

needle is attached to each syringe. Diphtheria, tuberculosis, tetanus, septicemia, bubonic plague and other diseases are treated by antitoxin inoculations. The mortality rate in diphtheria, which, until the use of antitoxin used to be fifty per cent and over, has through the instrumentality of this agent been reduced to three per cent when used sufficiently early in the case.

Power of Antitoxins.

Antitoxins are said to have the power to render inert bacteria that may already be present in the subject treated, or to bring about such alterations in the tissues of the body as will prevent their development and a cure is the result.

There are four steps necessary in the preparation of antitoxins:

I.—The germs are obtained and grown in a proper substance under suitable conditions until the toxin or poison is produced.

II.—The toxin is introduced in gradually increased doses until protection is obtained. (A dose, we are taught, can be borne toward the last of the treatment which if given at first would have caused instant death.) Some authorities tell us the process takes from *three to six months.* Others give the period as from *six months to two years.*

III.—Some of the blood of the immune animal is next removed; aseptic precautions are observed during its removal. After coagula-

tion, the serum is taken and its protecting power tested in other lower animals.

IV.—It is put up in tubes or containers to which a needle is attached, these are sterilized, and carefully and aseptically sealed, ready for the use of the human subject.

Vaccination.

The antitoxin treatment is somewhat similar in its effects to vaccination as a protection against small-pox. The theory has been advanced that vaccination against diphtheria and other communicable diseases may come to be an established method during epidemics.

Koch's Circuit.

It is claimed by Koch that in order to prove that a certain germ or micro-organism is the cause of a specific disease it must produce certain effects. Briefly, these are as follows:

I.—Where the disease is present there the specified germ must always be found.

II.—The germ found in the diseased body must again grow and multiply in proper culture media outside of the body.

III.—The same disease must be reproduced in a healthy animal by using the poison or toxin obtained from the culture media in which the germ has multiplied.

IV.—The same germ must again be found in the serum of the blood of the animal thus inoculated as a result of the process.

Koch further states that it must be proven that no other germ is capable of producing the

disease under consideration and that if the original micro-organism is not found all through the process the suspected disease does not exist.

SUMMARY OF CHAPTER IV.

Parkes' list of diseases due to bacterial invasion. How they are communicable.

Different opinions of authorities on this point.

Manner in which bacteria gain an entrance to the human structure.

The periods of incubation, invasion and development of disease if the bacteria are not overcome by the phagocytes and other antagonistic cells of the body.

How infection is thrown off from the healthy body.

Death of bacteria through lack of nourishment and other causes.

Immunity: Natural, acquired, artificial and definitions.

The opsonic theory.

Antitoxins: Where they are obtained and how they are prepared.

Koch's Circuit.

CHAPTER V.

COMMON COMMUNICABLE DISEASES.

Contagious and Infectious.

In former years communicable diseases were spoken of as either contagious or infectious diseases. The term contagious was applied to those diseases which are transmitted by direct contact or inoculation; infectious to those which are either air or water borne. It has been developed by experience that many of the diseases which were called infectious can also be transmitted by contact or inoculation and also that those diseases termed contagious are sometimes air or water borne, hence the apparent necessity for the change to the term communicable which is used to cover all diseases that may be transmitted or communicated from a sick to a well person without reference to the method of transmission or communication.

Communicable Diseases.

Among the communicable diseases commonly met with by the nurse we will first mention

Bacillus Typhosus.

TYPHOID FEVER. The invading microorganism in this disease is the bacillus typhosus, a facultative anaërobe, discovered by Eberth and Koch and sometimes called Eberth's bacillus in honor of one of its discoverers. The bacillus typhosus is about 1-10,000 inch long and about 1-40,000 of an inch in thickness. It has power of motion, flagella

The Peyerian Glands.

surround it on all sides. It does *not* form spores. The seat of invasion in typhoid fever is the small intestine in the lower part of what is known as the ilium, situated near the ileo-caecal valve. The bacillus first attacks certain structures termed the Peyerian glands (also termed "Peyer's patches," after the anatomist who first discovered or described them). These glands are small white looking patches, or groups of lymph follicles, (tiny sacs containing great numbers of small, round cells and some fluid) in the mucous and submucous layers of the lower part of the small and the beginning of the large intestine. As a result of the attack, the Peyerian glands inflame, swell, thicken and frequently ulcerate.

Changes Produced.

When ulceration occurs sloughing or casting off of dead particles of tissue follows and an open sore is left behind. Sometimes a blood vessel is punctured by an ulcer, when a hemorrhage more or less severe in its effect takes place.

Hemorrhage.

An ulcer may, and frequently does, extend through the entire wall of the intestine, when perforation and the escape of the intestinal contents into the abdominal cavity causes peritonitis and death, unless the perforation is such as can be repaired and the patient is in a condition to warrant such a measure.

Perforation and Peritonitis.

While the small intestine is said to be the

chief seat of the bacterial invasion, the various systems of the human structure are also affected.

Absorption of Poison.

There is elevation of temperature, due to absorption of poison produced by the bacillus typhosus, and the patient generally suffers from thirst.

The Nervous System.

A disordered condition of the nervous system exists, manifested by headache, insomnia, and in severe cases by delirium, unconsciousness and other very grave symptoms, described by authorities as "the typhoid state."

The Digestive System.

The digestive system is affected and in consequence we observe loss of appetite, a furred tongue and sometimes nausea and vomiting. At times there is a severe diarrhœa present, at other times constipation may exist.

The Circulatory and Respiratory Systems.

There are disturbances, too, of the circulatory and respiratory systems. The heart beats more rapidly and there is a corresponding increase in the pulse rate. There are characteristic changes in the respiration, also, very often.

The Skin.

Changes in the skin are apparent, and it is usually found to be hot and dry during the height of the fever.

The Muscular System.

The changes in the muscular system are shown by their thin, flabby condition, which is especially noticeable if the disease runs a prolonged course.

The Urine.

Changes are observed in the urine owing to an increase of the solids contained therein. It

is highly colored and diminished in quantity usually.

Excretion of Germs.

The germs of typhoid fever are thrown off in the evacuations from the bowels, in the urine, in vomited matter, in the desquamating skin, in the rose spots, in pus from suppurative complications, and may be found in the blood and in the sputum and sordes (foul substance which collects on the teeth and gums of fever patients). Flies are known to distribute the infection. The feet of a fly are equipped with pads and claws, two pairs of these on each foot. Each of these pads is covered with many thousands of tiny hairs to which millions of pathogenic bacteria adhere as the fly feasts on the filth it loves and which it has no trouble to find on the premises of the uncleanly. Straight from its haunts, the deadly fly will come into our homes and our hospitals if all doors and windows are not carefully screened. It deposits the deadly germs it carries on the food in the diet kitchen, in the milk pitcher, and everywhere it alights. This is only one way in which they are dangerous. They lick these deadly germs from off their feet and swallow them. Increased a thousand-fold they are again deposited as excreta, and they will be deposited anywhere that flies are harbored. The common method of communication is through contaminated drinking water, milk and food

Common Methods of Communication.

Contaminated Milk.

supplies, flies may cause this contamination. Typhoid germs multiply rapidly in milk. *Milk may be contaminated also, (1), because the cows are not kept clean; (2), because milk pails, cans or other vessels in which milk is kept are not thoroughly cleansed and boil-

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* In the best dairies and creameries now-a-days the milk is Pasteurized in sterile receptacles. Water used to wash the butter is boiled in covered apparatus, and then cooled to the proper temperature in specially constructed refrigerators. Special care is taken to sterilize all cans, pails, etc., used for the milk and butter. The cows are kept clean, and the milkers' hands and clothing also, both in milking and in handling the milk afterward. Butter made in these dairies and creameries, according to agricultural journals, *keeps months longer* than when *made and taken care of in the old-fashioned way.*

"Pasteurization of Milk" in the Control of Communicable Diseases.—The Journal of the American Medical Association, October 23, 1915, gives a review of this subject as recommended by the *Bulletin,* the monthly organ of the State Department of Health of New York and the *Health News.* The *Bulletin* calls attention to the fact that too many deaths due to typhoid fever, diphtheria and scarlet fever have been reported. These three diseases, together with measles and whooping cough, were responsible for the 5,000 deaths among young children in New York State in the year 1915. This issue of the *Health News* contains an account of four outbreaks of communicable diseases: Septic sore throat in Westchester County by contact and secondarily by milk; scarlet fever in Duchess County was spread primarily by milk and secondarily by contact; diphtheria in Rockland County by milk and in Westchester County by contact. Therefore, the remedies which would guard against such outbreaks are simple—pasteurization of milk and isolation of early cases. These four epidemics included nearly 1,400 cases. This lesson is therefore emphasized. Unpasteurized milk is unsafe. Health departments should require the pasteurization of milk before delivery to consumers, in order to prevent outbreaks.

ing water poured into and over them before using; (3), because the dairy is not kept pure or persons handling the milk are not careful; (4), because water, which some dishonest dealers are said to put in the milk they sell, may contain the germs. Epidemics of the disease are common and are often traced to a contaminated water supply. Hence the necessity for filtering and boiling the water used for drinking and in preparing food, especially during epidemics. We cook our foodstuffs to make them safe, and use sterile water to cleanse fruits and vegetables which come to the table uncooked, and on the outside of which germs of disease are often deposited by flies and floating dust. We keep milk* and meats, unless already contaminated when purchased, unharmed by placing them on ice. An epidemic of typhoid fever occurred in Butler, Pennsylvania, in 1903, the horrors of which are still fresh in our memories. The death rate was enormous. Many nurses lost their lives. An infected water supply was the cause.

Sterile Drinking Water.

The Butler Epidemic.

Prophylaxis.

Great care is necessary on the part of the nurse who attends typhoid fever patients to guard all sources of infection under her immediate control. Separate dishes must be used

* It is now considered much the safer plan to use pasteurized milk for all purposes. The difference in price between this and the raw product is very small.

for such patients, and these must be *kept separate* and cleansed by themselves. They must be disinfected each time after using by pouring over them boiling water, and they must be boiled for at least ten minutes once daily, also. Stools and urine and vomited matter must be thoroughly disinfected before they are emptied. Use a sufficient quantity of good disinfectant solution, boiling water, milk of lime, carbolic acid, etc. (See Chapter VII for disinfectants), to completely saturate the mass. *Cover the vessel* and allow it to stand for an hour before disposing of its contents. Thoroughly cleanse and disinfect the vessel and its cover each time after using and as a matter of precaution keep a small quantity of a disinfectant solution in all vessels preparatory to using again. If you are using carbolic acid for this purpose, be very sure to thoroughly wash it out before giving the vessel to your patient. Severe burns have been caused by failure to perform this most important duty. All such vessels should be boiled once a week, at least.

Care of Appliances.

Use a separate thermometer for typhoid fever patients and also separate bed-pans, urinals, syringes and rectal tubes. Keep the thermometer in a bichloride solution, 1-1,000, renewed daily. Be very particular to cleanse the rectal tubes and syringes and boil them every day. Bed-pans and urinals should be boiled in a soda solution at least

once a week. *Never turn syringe nozzles inside of syringes after using.* This is a common error. Infected fecal matter is carried by the nozzle to the inside of the syringe, thence to the tubing—where it is difficult to reach. Remove the nozzles; scrub well with soap and hot water before boiling. They should be kept in a carbolic acid solution, 1-40 (2½ per cent), as are the rectal tubes. This solution must also be prepared anew once in twenty-four hours. See that bed and body linen and towels are disinfected before placing in the laundry with the ordinary wash; these should be soaked for at least two hours in a hot 1-20 (5 per cent) carbolic acid solution. Burn all pieces of old linen or absorbent cotton used to cleanse the mouth and teeth and lips. Use listerine, borolyptol or other good solution for this purpose. Give particular attention to cleansing and disinfection of the sick room at the close of the case and of everything it contains.

Typhoid Carriers.

The bowels and kidneys of some typhoid fever patients retain the bacilli for years, and these are given off in the urine and bowel evacuations. Such persons are for this reason a serious public menace. They are called "typhoid carriers."

The Patient's Room.

In nursing communicable diseases outside the hospital when preparing your patient's

room ask permission to remove all unnecessary furniture and draperies, etc., which may serve as lurking places for germs. Explain when you ask permission why you would like to have the room as nearly on the hospital order as possible. If you are allowed a choice of rooms, one with plenty of windows for ventilation and on the south side of the house is preferable so as to get plenty of sunlight, and it should be as far removed from noise and disturbance, especially of kitchen, dining-room and street, as you can get it.

Personal Hygiene.

TAKE CARE OF YOUR OWN HEALTH. Be very careful to thoroughly wash and scrub your hands (particularly your nails, beneath which are favorite hiding places for germs), and disinfect them each time you attend to the evacuations. *Never touch your face* with your hands after such work until they have been carefully cleansed and disinfected. A tiny speck of any one of the discharges may be deposited upon the face or lips and gain an entrance to the body with disastrous consequences to you. Be watchful of like dangers when giving baths, enemas and in cleansing the lips, the teeth, the mouth and the finger-nails of your patient.

General Precautions.

Pay strict attention to personal disinfection before going from a communicable disease to another case.

Keep your patient's person, bed, bedding and room absolutely *neat and clean.* Pay special attention to cleansing the mouth and teeth and lips between the hours for feeding and before administering food or stimulant or medicine, as well as after the bath, particularly in severe cases where sordes collects so rapidly on the teeth and lips. Dust all woodwork and furniture with a cloth wrung out of a hot disinfectant solution. Floors also should be washed every day with a hot disinfectant solution. Pay strict attention to ventilation. Remember that neatness and cleanliness are necessities, and that an abundance of fresh air and sunshine are Nature's own disinfectants. Two to three thousand cubic feet of fresh air are required in all sick rooms; the latter amount is obtainable in a room fifteen feet wide by twenty long, with a ceiling elevation of ten feet, but the current must be changed every hour in order to keep the atmosphere pure. Your patient can be protected by a screen from her possible fear of "catching cold" while you open up the windows from the bottom. They should be kept open a few inches at the top all the time. All "disease germs" multiply rapidly in a room kept dark, dingy and badly ventilated, and where papers, books, and rubbish are allowed to accumulate. The sick one takes these germs into the system again and the disease is both aggravated and lengthened.

Fresh Air and Sunshine.

Alcohol Rub.

*Study to acquire right methods of bathing in this disease. Do not forget the importance of the cleansing bath using warm water and good soap every morning, followed by an "alcohol rub" and careful powdering of the back and other parts of the body where pressure is observed or friction is noted due to contact with the mattress. Change your patient's position frequently from side to side unless the physician in charge instructs you otherwise. This will not only be a comfort to the sick one, but will in conjunction with the warm cleansing bath and alcohol rub, which should be frequently repeated, aid in the prevention of bed

Change Patient's Position.

* While it is not the purpose of the writer to speak of all methods of treatment given in diseases caused by bacterial invasion, several years' experience in training nurses has revealed the fact that many pupils fail to grasp the proper method of applying hydrotherapeutics when nursing typhoid fever. If the physician orders tub baths, they seem to fail to recognize the necessity for using friction systematically in order to bring about the requisite reaction. When they do use friction, they go about it in such a haphazard fashion that frequently there is an increased elevation of temperature instead of a decreased, and the nervous symptoms at the end of the treatment are more pronounced than before beginning it. (This does not refer to patients whose peculiarities of constitution are such as to contra-indicate "tubbing," but to those who, when properly handled, respond admirably). In giving sponge baths, also, very often the right method of sponging is not observed. It seems to be necessary for nurses who are training pupils to pay particular attention to *practical* teaching in this direction. While lifting the patient out of bed for the old-fashioned tubbing has practically become a thing of the past, bed tubbing, in which a tub is improvised by means of pillows and rubber sheets, is still prescribed by many physicians and the same routine is practiced.

sores, the occurrence of which in almost all cases is due to lack of care and watchfulness on the part of the nurse. Turn your patient's pillows often and shake them up thoroughly before replacing them under the head. If the physician orders ice caps on the head and abdomen, see that they are *kept filled* with ice *and not with hot water.* To allow the ice to melt and become hot water does more harm than good. When the physician says "ice caps" he means ice caps and not hot water bottles. Do not forget to keep the finger-nails clean and the hair neat, if the physician does not order the hair clipped.

Ice Caps.

The care and watchfulness necessary in nursing typhoid fever holds good in nursing all germ diseases. It will therefore be unnecessary to speak of these at length when dealing with other communicable diseases.

Typhoid Vaccine.

Hypodermic injections of typhoid vaccine or serum have come into favor in recent years in the treatment of typhoid fever cases, and also as a preventive measure. It is administered to physicians and nurses, and to "typhoid carriers" as well (see anti-typhoid vaccine, page 217, serum therapy), as to others who have not had the disease.

A Blood Test. If there is reasonable doubt as to the disease from which a patient is suffering being typhoid fever, a test discovered by

Widal, of the University of Koenigsberg, is usually resorted to.

"Widal's Test."

Widal's Test is based upon the fact that the blood serum of a person who has typhoid fever is antagonistic to the bacillus typhosus. After aseptic precautions have been carried out, a drop of blood is obtained from the suspected patient by pricking the lobe of the ear with a sterile needle. This drop is placed on a sterile cover glass and covered with a special slide *at once,* to prevent other germs which may be lurking about from getting into it, and it is then allowed to dry. A little of the bouillon, or other substance, in which the bacillus typhosus is being cultivated is then placed on another sterile cover glass. The dried blood, or serum, of the suspected patient is made into a watery solution and added to the culture. From this mixture of dried blood and typhoid bacillus, what is known as a "hanging drop"* preparation is made and studied under the microscope. If the patient has typhoid fever the bacilli will be seen rapidly to lose their

* In preparing the "hanging drop," a slide in which a slight hollow, or depression, has been made, is used. A drop of the watery solution of blood serum and bacillus typhosus culture is placed on a sterile cover glass and then inverted over the hollow in the slide. The drop thus hangs free between the cover-glass and slide and the peculiar actions of the bacillus may more readily be observed under the microscope. The "hanging drop" method is used in the examination of other cultures, pus, etc.

power of motion and to form into tangled clumps, or masses, and so get away from the blood serum of the patient. If typhoid fever does not exist, this clumping and entanglement of the bacilli and arrest of their movements does not occur. There is an exception to this rule in cases where the patient has had the disease recently, under which circumstance the reaction may occur without such evidence of the onset of a new attack. Also, the patient must have had the disease for, at least, one week or the test will fail.

Exception to **Widal's Test.

Cholera and Dysentery.

CHOLERA is caused by Koch's comma bacillus, so called because it is a short comma-shaped rod. It is also called *spirillum cholorae Asiaticae*. This bacillus is an aërobe, it possesses power of motion by means of a single flagellum which occurs at one end, and it does not form spores. Dysentery, a somewhat similar disease, is caused by the bacillus dysenteriae—both of these diseases are contracted through the same sources as typhoid fever is contracted, and the same watchfulness against its spread must be rigidly carried out; also the same precautions as to personal cleanliness and neatness with

**German authorities spell this scientist's name *Vidal*, and assert that he is French and that the American spelling, "Widal," has arisen because of the German pronunciation of the letter V. The French alphabet does not contain the letter W.

regard to the nurse, patient, and patient's room. Be especially careful to let the pure air and sunshine have free access at all times, and remember the danger from impure water. Epidemics of cholera from that source are not common here. An epidemic occurred in Hamburg, Germany, in the months of August and September, 1892, when nearly nine thousand deaths were reported during the two months. The epidemic was believed to be due to the infection of the river from which that city obtains its water supply. Gipsies had camped on the river banks, and as they had a case of cholera in their midst, the trouble was thought to have arisen from that source. The disease is one which belongs to India and the Orient, but may be carried to other countries, as in the Hamburg epidemic. It has been carried to this country, also, but not in recent years. Immigrants are carefully watched when they come into our large ports and all "suspects" are placed in quarantine.

Sources of Infection.

The Bacillus Diphtheria, usually called the Klebs-Löffler bacillus, after the men who first discovered it and grew (or isolated) it in culture, is strictly an aërobe; it does not possess power of motion, does not form spores, but produces powerful poisons or toxins which are absorbed and which not infrequently affect the action of the kidneys, the nervous system

and the heart. Von Behing and Ehrlich in 1893 discovered and first prescribed the use of diphtheria antitoxin not only in the treatment of diphtheria, but as a preventive. It should be given early in the case, to be effective, in overcoming the toxins. 3,000 to 10,000 units* is the dose given during the attack; 1,000 units is the prescribed dose to be given to produce immunity in other members of the family where a case arises, and is especially necessary where there are other children. The bacillus diphtheriæ, the micro-organism of diphtheria, can be taken into the system in food. It will live for weeks on slate pencils, drinking cups or glasses used by school children and which become contaminated from their mouths before the disease is discovered. It may also be communicated from the sick to the well directly from the mouth, indirectly through articles used in the sick room, such as infected dishes, books, toys, spoons, or other similar articles. It may be carried in the clothing, upon the hands of the physician or the nurse, or the infection may be breathed in. The germs are found in the discharges from the nose and throat. The nurse must be careful to avoid having the patient cough in her face, as particles of membrane dislodged from the throat are a fruitful source of danger, especially so to both

Slate Pencils.

Intubation and Tracheotomy.

*A unit is the amount required to save a 300 gm. guinea-pig from death from ten times the smallest fatal dose of diphtheria toxin.

physicians and nurses during operations on the throat (tracheotomy and intubation of the larynx), for the relief of patients suffering from this dread disease. Protect yourself by having your patient cover the mouth with a paper napkin or piece of gauze while coughing, these to be *burned at once.* Such particles may, also, adhere to the clothing or hair, etc., and be carried to others. Therefore be careful to wear a gown and cap, and have these, also, for the physician during such operations.

While the seat of invasion in diphtheria is usually the throat, other parts of the body suffer, also, from the effects of the powerful toxins or poisons, which is always the state of affairs in severe germ diseases. A common sore throat forms a good camping ground for the diphtheria bacillus and the deadly work is accomplished very rapidly in many instances. Patients sometimes die before their danger is realized by the uninitiated. Suffocation, heart failure and exhaustion are immediate causes of sudden death. Paralysis, although not often fatal, may occur through absorption of toxins by the nervous system. The nurse must be ever on the alert for symptoms of approaching danger from any of these sources.

Isolate and Disinfect.

Isolation must be rigidly carried out. Disinfect all discharges from the throat and nose; all bed linen, towels, gowns, spoons, dishes and

all sick-room appliances with boiling water, or with hot carbolic acid solution 1-20 (5 per cent). Wash all woodwork, floors and furniture with one per cent carbolic acid or bichloride of mercury solution 1-4,000 during the case.

Ventilate. Be careful to protect your patients from any possibility of drafts striking them. Use a screen about the bed. No patient's bed should be so placed as to be in a current of air. A room properly ventilated is not "drafty" of necessity.

Do not forget that *absolute cleanliness* of the *patient,* the *nurse,* and the *room* and the use of disinfectants throughout the case (especially *fresh air and sunshine,* nature's own disinfectants) are of *greater value* than disinfection and fumigation at the end of the case. (Sunlight will kill the germs outside the body in half an hour.) Not only is this true in nursing diphtheria, but in nursing all other communicable diseases. In many of our large cities Boards of Health are discarding rigid measures of fumigation when a nurse has been in attendance who has faithfully carried out modern methods of nursing, and when she has, also, been careful in her preparation of the room to remove from it all rugs, window draperies and all unnecessary pieces of furniture in which germs lodge. **Fumigate.** As a safeguard, however, many still teach fumigation.

Membranous Croup and Whooping Cough.

Membranous croup and whooping cough are contracted in the same way as diphtheria, and are spread by the same means. Moist air is necessary in the patient's room in most cases of diphtheria, whooping cough and croup to relieve the throat symptoms.

INFLUENZA OR LA GRIPPE.

The bacillus influenzae, the germ of this disease, finds an entrance to the system through the respiratory tract. It is an aërobe. It does not possess power of motion and it does not form spores. It is one of the smallest of the pathogenic bacteria. Sources of infection are the discharges from the throat and nose, which should always be disinfected. Epidemics are common.

Pandemic in 1918-1919.

In the Autumn of 1918 an almost worldwide epidemic of what was called "Spanish influenza" raged. Its fury did not abate until the late Winter of 1919. Its toll of death from a peculiar form of pneumonia complication was estimated as greater than the entire number of deaths due to the "World War." In addition to the bacillus influenzae, several forms of pneumococcus and streptococcus were found in the lungs at postmortem examinations. A less severe outbreak again occurred in the Winter of 1920. (See page 223 for vaccine treatment). There were fewer fatalities.

SCARLET FEVER, MEASLES, GERMAN MEASLES, CHICKEN POX.

Methods of Communication.

The germs causing scarlet fever, measles, German measles (Roseola) and chicken pox are found in the secretions from the nose and throat and in the desquamating (peeling or flaking) skin. While the germ of this disease has not yet been isolated, a streptococcus infection seems to be a complication in many cases. The anti-streptococcus serum is used by some practitioners in the treatment of such cases. The disease may be contracted through direct contact with the afflicted person, articles used in the sick room, such as books, toys, clothing, food or dishes, and also from dust and sweepings of the ward or room. This is especially true of scarlet fever and measles, and the nurse needs to be more than ordinarily cautious, as the disease can be communicated to the well just as long as any desquamating skin remains. Disinfection before desquamation ceases is practically *a waste of time.* While some are beginning to teach that books, toys, clothing, desquamating skin, etc., do not carry infection, this theory yet remains to be proven. So let us still continue our vigilance in this direction.

Domestic Animals.

Cats and dogs are believed to carry the germs in their coats and should be kept out of the sick room. Use carbolized oil as an inunction in all of these diseases

to prevent or lessen the danger from floating particles of skin. Gowns and bed linen, which are full of these particles, should be removed carefully, wrapped in a sheet wrung out of a disinfectant (two and one-half per cent carbolic acid solution), and placed *at once* in a disinfectant, the same strength hot carbolic acid solution. Do not shake them about the room. Wash all furniture, woodwork, window-sashes and floors with a cloth wrung out of a one per cent carbolic acid solution during the case. Destroy all toys, books, etc., used by a scarlet fever patient, by *fire preferably,* at the close of the case. When nursing scarlet fever in a private home, if at all possible, obtain two well ventilated, sunny communicating rooms in the top story of the dwelling in which to isolate your patient. Have everything you may need for the care of your patient and yourself in the room adjoining the sick room, in order to avoid the danger of carrying infection to other parts of the home. If others must frequent the corridor outside the rooms you have chosen, keep a sheet wrung out of carbolic acid solution (1-20), five per cent, spread over the outside of doors that communicate with that hallway or corridor. Place over any opening that may be at the bottom of the doors a towel or cloth saturated with the same solution. Keep in the closet of the adjoining

Preventive Measures.

room a change of attire to be worn on the street if you are allowed to go out for an airing, and be careful not to place in this closet anything you have worn or used in the sick room. Keep in this room disinfectants for your own and the physician's hands and for disinfecting articles used in the sick room. The physician will also probably leave with you his gown, cap and rubber-soled shoes, which he wears to protect his street garb when he makes his daily visits. These you must also keep in the adjoining room where the physician dons them before seeing his patient. If your meals are sent up to you from the general kitchen, be sure to disinfect the dishes, the tray and everything on the tray before placing it in the corridor to be carried down stairs. A small ice chest in which to keep articles of food, such as pasteurized milk, eggs, etc., is a great convenience, in fact almost a necessity, and should of course be placed in the room adjoining the sick room. After desquamation ceases your patient must be treated to several baths containing a disinfectant before mingling with other members of the family. Nothing worn in the sick room may be placed on your patient after the bath. Use the same routine in all diseases in which there is desquamation. Be very thorough in fumigating and cleansing, also in personal disinfection before going to another case.

Sources of Communication Unknown.

MUMPS. In mumps it is deemed wise to disinfect discharges from the throat and nose. Although it has not yet been proven how the disease is contracted, it is conceded by all to be a communicable disease.

Bacillus Tetani.

TETANUS, commonly called "lockjaw," is caused from the invasion of wounds by a germ known as bacillus tetani, usually found in the soil near the surface, and also in dirty floors of stables and cellars. The bacillus tetani is an anaërobe. It possesses power of motion and it forms spores. It has flagella on all sides and when observed under the microscope may be seen to glide across the field of vision. The spore, before detaching itself from the parent bacillus, is located at one end of the rod, giving it a very peculiar appearance. It resembles a tiny tack or nail. This spore resists heat, drying and disinfectants more than that of almost any other known bacteria. A temperature of 105° F. for ten minutes will, as a rule, destroy both the tetanus germ and its spores. This is not always the case, as these spores have been found alive in ground earth, on wood, or splinters of wood, that had been protected from sunlight, after a number of years and have again caused the disease. The poisonous matter is thrown off through pus discharged from punctured wounds. We frequently meet with cases of tetanus

caused by the patients having stepped on a nail protruding from a board lying in their pathway. The nail has penetrated the shoe, entered the foot and carried with it particles of soil containing the germs. The bacillus tetani is said to possess the power to do its deadly work in as short a period as twenty-four hours, and but rarely to cause mischief later than the tenth day after the accident, although the disease has been known to develop as late and later, than the third week after infection.

Fourth of July Toy Pistols.

In past years numbers of cases of tetanus have occurred after Fourth of July celebrations, arising in wounds caused by toy pistols. Blank cartridges of these toys were believed to contain the germs, although authorities are of the opinion that the germs were probably upon the *soiled* hands of the child before the accident and that they caused trouble in the wound afterward just as they do in other gunshot accidents in which tetanus arises. Deaths were reported in 1920, although a law was passed in 1903 in many of the large cities of the United States prohibiting the sale of these pistols.

Symptoms.

The throat and jaws seem to be the parts most affected when the symptoms first appear. A feeling of stiffness and sometimes of pain in these parts is complained of. Rapidly the stiffening of the jaws increases. Severe

muscular spasms develop, at first in the muscles of the jaw, but soon to spread over the entire muscular system. The spasms increase in rapidity and severity until they are kept up almost continuously. (The spasms seen in tetanus are somewhat similar to the spasms from strychnia poisoning.) Eventually the jaws become tightly clenched, the back is bowed and the patient is frequently found to rest only on the back of his head and his heels, the rest of the body arching upward from the bed. Death commonly occurs from exhaustion. The majority of cases used to prove fatal.

Arching of the Back.

Effect of Medicines.

Medicines seem to have no effect in arresting the progress of tetanus. Chloroform and opiates are used by many physicians for the temporary relief they give from the violence of the spasms. In recent years the antitoxin treatment has saved many lives. In order to be of any value it must be administered early in the case; in fact, before any symptoms arise. When given immediately (1,500 units) after infection is suspected in cases of deep punctured wounds, gunshot wounds, and so forth, it is proving an absolute preventive of tetanus.

Antitoxin a Preventive.

A new method for the preparation of the tetanus antitoxin which had been experimented with during the war has recently been discussed by Dr. W. E. Robertson, Professor of Pathology, University of Minnesota, in the *Journal of*

the American Medical Association (August 28, 1915). Liquid tetanus antitoxin was poured on pads of sterile absorbent cotton in such amounts as to render the cotton uniformly moist, but not wet enough to drip. These pads were then dried for twenty-four hours in a moderate heat (40 to 45 C., 104 to 113 F.) A previously sterilized evaporating dish or earthenware mortar, covered with a double layer of filter paper, was found satisfactory for this purpose. The dried antitoxin cotton became a stiffened mass, resembling dried paper pulp. This was weighed and divided into pieces which by weight would represent definite quantities of antitoxin; for example, if the entire mass weighed twenty units of dried antitoxin, one-twentieth by weight would represent about one unit. When the prepared cotton was bound on freshly made wounds of mice, rats or guinea pigs, protection was given against the later injection of many times the minimum fatal dose of tetanus toxin or against the simultaneous inoculation of a garden earth which had been proved by numerous tests to produce tetanus in 100 per cent of cases of unprotected rats and guinea pigs.

Management of Tetanus.

In the treatment of tetanus, the nurse is instructed to keep the patient's room darkened and to guard him from all disturbances. Noises are said to aggravate the spasms,

and she is cautioned to keep him quiet. He should be watched very closely and must not be left alone a minute. Strenuous efforts to give him nourishment must be made. As the jaws are tightly clenched, recourse is had to nutrient enemata. "Nose feeding" is not recommended by the best authorities, as it is believed to aggravate the spasms. Opiates are sometimes given by rectal injection also.

Preventive Measures.

The best authorities now recommend opening up accidental wounds as quickly as possible after they occur. A thorough irrigation of the wound with an antiseptic solution then follows, such irrigation to be kept up at frequent intervals until all danger of the invasion of the bacillus tetani is over. These authorities advocate leaving the wound open to the air after irrigation, claiming that as the bacillus tetani is an anaërobe which cannot live in the presence of air, this is the rational method. In connection with this treatment, the tetanus antitoxin is given immediately after the accident occurs as a precautionary measure. Even more than *strict regard* must be paid to disinfection and cleansing during the case and at its close.

Cause of Erysipelas.

ERYSIPELAS, at one time regarded as an acute inflammation of the skin, is now attributed to the invasion of the system by the strep-

tococcus pyogenes* which gains an entrance through wounds, and sometimes through scratches or punctures of the skin so tiny as to be almost imperceptible to the naked eye. The disease is spread by means of small particles of desquamating skin from the affected part floating in the air and by pus from the wound in some cases. It is carried from one person to another by actual contact, clothing, or other infected articles, such as dishes, bedding, towels, dressings, and anything used by patients. It may also be communicated by the hands of the physician or nurse or by instruments used in treating the case. All such outlets and inlets of this most mischievous germ must be well guarded by the nurse. Burn all old dressings immediately and use disinfectants rigidly throughout the case and at the close of the case. All cases must be isolated and given to the care of a special nurse. The "eternal vigilance" ordered in the nursing of scarlet fever and other desquamating diseases must be rigidly adhered to in erysipelas.

Channels of Outlet.

Isolate Your Patient.

While the erysipelas germ is liable to attack wounds, the disease frequently appears where there is no perceptible wound. A rose-red blush of the skin is seen. The edges of the

*When the streptococcus pyogenes invades the skin we have erysipelas; when it invades the blood, we have septicemia or "sepsis," and other inflammations in which suppuration occurs.

affected area are clearly distinct from the healthy surroundings. There is usually a swollen condition and the sick one complains of a tightness and stiffness in the diseased region. Erysipelas spreads rapidly when it attacks loose tissues, such as those of the face, and preventive applications have to be made early in the case. It is a very severe disease in some instances, particularly so in persons addicted to the habit of using alcoholics to excess.

Alcoholic Subjects.

Various parts of the system are affected as shown by elevation of temperature, nausea, and frequently vomiting, headache, rapid pulse, and after the disease is well advanced in bad cases there may be delirium and exhaustion. The disease frequently proves fatal. Cleanse, disinfect and *fumigate* rigidly.

TUBERCULOSIS. The bacillus of tuberculosis, or tubercle bacillus, is about 1-10,000 of an inch long and 1-75,000 inch in thickness. It is strictly an aërobe. It does not possess power of motion and it does not form spores. All forms of this disease, which attacks various parts of the human structure, are caused by the bacillus tuberculosis. Tuberculosis of the lungs is called phthisis or consumption. When the germs attack the lymphatic glands the disease is spoken of as scrofula. Tuberculosis of the skin is termed lupus. The nurse meets with tubercular joint disease, tubercular disease

of the kidneys, tubercular meningitis, tubercular peritonitis and so forth.

Methods of Entrance.

The germ which is responsible for the development of tuberculosis generally gains admission to the system through breathing in air in which they are circulating, through dried sputum, or pus, which instead of being burned, careless nurses have allowed to be disseminated through the air in floating dust, but it may be taken in through other sources; for instance, by drinking milk containing the germs. Jersey cows are said to be subject to tuberculosis and their milk apt to contain the germs. Wounds also admit them.

Predisposing Causes.

Persons predisposed to tuberculosis are those whose chests are not well developed, whose circulation is poor and whose vitality is low, particularly if their surroundings and occupations are unhealthy. Those who have to work in dusty, overheated, badly ventilated rooms, for example. Insufficient or poor food is given as another cause favoring the development of the disease. When one of these causes, or several of them, weaken the structure, power of resistance is lessened, and when the germs gain an entrance to the human machine we fall an easy prey to the ravages of the disease, if they are not sought after and driven out at an early stage.

Because of its tremendous mortality rate, to

tuberculosis has been given the name, *The Great White Plague.*

Early Precautions.

The duties of the nurse when caring for a tubercular patient are to thoroughly disinfect all sputa, cleanse and disinfect all sputa cups, and to destroy *by fire all dressings* used on tubercular wounds. Many physicians demand that *sputa be burned* also, and special sputa cups are now in use with a detachable waterproof lining made of a sort of pasteboard. These linings are put up in packages which come with each sputa cup. They are easily slipped in and out and are changed several times a day. They are burned *immediately* on removal from the cup. Bed and personal clothing (particularly handkerchiefs) must be treated to a bath of boiling water or well soaked in a good disinfectant (carbolic acid solution, five per cent) before placing in the general wash. Boil all dishes and vessels used for feeding and other purposes in a 2% sal soda solution *at least once daily* for ten minutes. While tubercular patients are not isolated in the same sense in which scarlet fever or diphtheria patients are isolated they should occupy separate bedrooms and the use by others of a tubercular patient's dishes should be STRICTLY FORBIDDEN.

Fresh Air Treatment.

Keep your patient out of doors in the fresh air and sunshine as much as possible. "Out of

doors *all the time,* and to sleep and eat in the open air in a proper climate" is getting more and more to be the prescribed treatment. To which is added as indispensable the serum treatment (in the early stage), plenty of nourishing, easily-digested food, especially an abundance of milk and eggs, perfect cleanliness and neatness of person and surroundings and a cheerful atmosphere at all times. The nurse who pays strict attention to all of these requisites is a valuable and *valued* assistant to the physician fighting this disease.

Serum Treatment.

The Mosquito Anopheles.

MALARIA. Malaria is due to the ravages of the germ plasmodium malaria, or, as it has recently been re-named, hemameba malariae, discovered by Laveran, of France, in 1880. The plasmodium malaria is an animal parasite; a protozoon, quite as minute as the vegetable bacteria to which most germ diseases owe their origin, but much more complex in structure and in its method of reproduction. It is a single cell parasite, as we have already stated all protozoa are, and is believed to be carried from the sick to the well by a species of mosquito —the anopheles.* Those who live in low, damp localities or near "swampy" regions are more apt to be attacked, as these are favorite

* In 1897 Ronald Ross, an Englishman, a surgeon in the English Army in India, began to teach that the anopheles alone is responsible for malaria infection.

haunts of the mosquito. In such places window screens and doors with a very close mesh should be used to prevent the invasion of the anopheles. The germs through the agency of the mosquito, get into the red corpuscles of the blood, live upon them, and destroy them. We are taught that there are three varieties of the malaria germ (as there are also three forms of the disease), one of which lives in the human structure seventy-two hours, and the other two forty-eight and twenty-four hours, respectively.* Their death, sad to say, does not mean the end of the mischief they accomplish, as when they cease to exist themselves, they divide up into a number of tiny particles or segments each of which means a new life or germ. These new germs attack other red corpuscles and live upon them until they, too, die, but in dying they form new parasites, as their parent germs did before them. Each fresh set of germs destroys a large number of the red corpuscles.

Plasmodium Malariae.

Length of Days and Multiplication.

This process of division and scattering of particles or segments, to form new parasites, gives rise to the chills, fever and the profuse

* The names given to the three forms or species of the plasmodium are, (1) plasmodium praecox, found in aestivo-autumnal malaria, living twenty-four hours; (2) the plasmodium vivax of the tertian form of malaria, the life of which is forty-eight hours; (3) the plasmodium malariae, found in the quartan form of malaria, which has a seventy-two hour life.

perspiring periods which characterize malaria. Some investigators tell us that these segments or particles are only capable of producing parasites of the female sex until several generations have been borne. Then sexual elements develop, but these are not capable of fertilization until they enter the stomach of the mosquito, anopheles. When the anopheles bites a patient who has malaria the blood thus procured enters the stomach of the mosquito. Here the male and female elements unite and become fertile. These fertilized elements are then taken up by the stomach walls of the mosquito where they give birth to an innumerable host of spores of a peculiar formation. These spores are then transferred to the salivary glands of the anopheles and from thence to the human victim when the insect attacks us. In the human victim the complete plasmodium once more develops and goes through the process of division and formation into female cells already described.

Mode of Communication.

Koch, and other scientists, who teach that the germ is carried by mosquitoes, believe they slake their thirst in infected pools in swamps and then alighting on healthy bodies they communicate to them the disease-producers by inoculation. Grassi, Bignami and other Italian workers have proven by their experiments that the theory of Koch of Germany and of other in-

vestigators in Europe and America in this regard is based upon fact. They also teach that these mosquitoes carry the poison in the same way from the sick to the well, and that two distinct life cycles are really possessed by the malarial parasite. These two cycles have already been mentioned. One taking place in the human patient and the other in the mosquito, anopheles. Prevention of malaria is only possible by destroying the mosquitoes.

Uncinaria Duodenalis

UNCINARIASIS, another disease caused by an animal parasite, the uncinaria duodenalis, is quite common in the United States as well as in other parts of the world, and is often diagnosed as malaria, some of the symptoms being similar. The seat of invasion in uncinariasis is the duodenum and the jejunum. Other names given to uncinariasis are hookworm disease, anchyloostomiasis, Egyptian chlorosis, etc. Hookworm disease is its common title. This name has probably arisen because of the peculiar bending backward upon itself of the anterior portion of the parasite, giving to it a hook-like appearance when observed under the microscope. The germs of uncinariasis are blood devourers and by means of peculiar tooth-like and suction appendages of the head they cling to the mucous membrane that lines the intestine. In this position they suck the blood

Blood Devourers

of their victims. A pronounced anaemia, of course, follows. This is one symptom found, also, in malaria. The plasmodium malariae causes anaemia by its power to destroy the red corpuscles of the blood. The germs of the uncinaria duodenalis enter the body in drinking water or from hands that have become soiled with dust containing the parasites. They are also said to be able to gain an entrance through the skin from whence they are carried by the blood into the right side of the heart and to the lungs. From the pulmonary blood-vessels they are thrown into the air spaces and carried upward to the bronchial tubes, larynx and into the oesophageal tract; then they are swallowed and finally pass into the stomach and from thence gain their camping ground, the intestine. The disease this micro-organism produces is frequently fatal. Diagnosis is made by examining a small particle of feces under the microscope.

The Germ a Diplococcus.

Cerebro-Spinal Meningitis is caused by the diplococcus intracellularis meningitidis. It is not communicated from the sick to the well in the same manner in which most communicable diseases are, and the germs are not found in the excretions unless there are lesions formed either of the brain or spinal cord. They are found in the cerebro-spinal fluid and in the nasal, throat and ear discharges of patients

who have the disease. The method by which the germs enter and leave the structure has been decided upon by scientists, as probably through the nose and throat, but nurses are instructed that it is safest to disinfect *all discharges from the body,* all personal clothing and bed linen; to keep the patient isolated; also to fumigate and thoroughly cleanse the room at the close of the case.

Seat of Attack.

The seat of invasion in cerebro-spinal meningitis is in the membranes which cover and enclose the brain and spinal cord. The germs set up an inflammation of these membranes, which are known as the meninges, but the poison is also distributed to other parts of the body. Inflammation of the meninges is a characteristic symptom by which the disease is made manifest. Sometimes only a small portion is affected, at other times the greater part of the cerebral surfaces are involved. This is one of the very few diseases in which the nurse is told that lack of strict personal cleanliness, so far as the patient is concerned, must sometimes be permitted because of the necessity for absolute rest and freedom from all movement.

Seventy-five to ninety per cent of the number of cases of cerebro-spinal meningitis used to end in death, and about eighty per cent of its victims were children under ten years of age. Since perfecting the anti-meningococcic

serum in the Rockefeller Institute, New York, through the efforts of Drs. Flexner and Jobling, its use has diminished the mortality rate to about twenty-five per cent *when administered early in the disease.* There have been epidemics of the disease in the United States, in which the death rate was appalling. The very best medical attention and most careful nursing are necessary to bring about recovery.

The Germ of the Disease.

PNEUMONIA. Pneumonia is one of the most serious of all diseases due to the invasion of the human structure by bacteria. The special germ to which this disease owes its origin is the diplococcus pneumonia, or "Fraenkel's diplococcus lanceolatus," which is also said to produce meningitis, pleurisy and ulcerative endocarditis. The disease produced in all cases is an inflammation, the manifestation of which is modified by the portion of the body invaded. Pneumonia is an inflammation of the lungs, sometimes of one or more of the lobes of one lung, sometimes of the lobes of both lungs, or it may be an inflammation of all of both lungs. Endocarditis is an inflammation of the endocardium or membrane lining the heart. Meningitis is an inflammation of the meninges or membranes which enclose and cover the brain and spinal cord. These various organs have various functions; this function is interfered with when the organ becomes in-

flamed and the symptoms are different, while the cause may be the same. The germ was discovered first in the lungs in pneumonia and took its name from that disease. As was mentioned in Chapter I, broncho-pneumonia is often caused by other germs, but authorities are of the opinion that in genuine, acute, lobar pneumonia the diplicoccus lanceolatus of Fraenkel is always present, and often the pneumo-bacillus. It does not possess power of motion; it does not form spores. It is found in the dust and sweepings of rooms and is frequently present in the mouths of the healthy. Exposure to severe weather or dampness which has produced a severe cold acts as a predisposing cause. The system is invaded, resistive power weakened, and an attack of pneumonia follows. The germs enter the lungs through the respiratory tract often causing disastrous changes in these organs. The poison is eliminated from the system through the secretions from the seat of the disease, usually the sputum, which should be disinfected or burned as in tuberculosis.

Why Named for Pneumonia.

Predisposing Influences.

Entrance and Exit.

Importance of Nursing.

Pneumonia has been called the "Captain of the Men of Death," because it carries off annually more victims than any other disease. In few other forms of illness is such constant care and watchfulness on the part of the nurse demanded as in pneumonia. The disease usually

ends by crisis, when collapse or great prostration of all the vital forces may occur. Or the patient may die during the course of a severe form of the disease from suffocation or heart failure. Such patients must not be left alone under any consideration. Heart failure is, perhaps, a point especially to be impressed upon the nurse, as any sudden exertion or excitement on the part of the patient may bring about the dread calamity. One attack of pneumonia instead of affording immunity, seems to predispose to other attacks.

Immediate Causes of Death.

Obermeier's Germ.

Relapsing Fever. Characteristic symptoms are *recurrent* paroxysms of high temperature separated by periods when the temperature is absolutely normal. The micro-organism which causes relapsing fever, discovered by Obermeier in 1873, is termed Spirocheta Obermeieri. Scientists are of the opinion that the disease is carried from the sick to the well by the bite of insects, although the actual method has not been fully determined. An epidemic of relapsing fever among the poor occurred in New York and Philadelphia in 1869. It is a disease of the uncleanly. It is not a common disease in recent years, and epidemics unheard of, owing to improved sanitary conditions.

Method of Communication Uncertain.

Filariasis is a disease due to the invasion of the system by the filiaria sanguinis hominis,

a small worm-like parasite. It is admitted to the body, usually, through the alimentary canal in impure drinking water. It is a disease of the tropics only. Mosquitoes are believed by some authorities to cause a spread of the disease by the inoculation of their victims with the blood of diseased persons. The seat of the disease is the deeper lymphatics. Prominent symptoms are chyle in the urine, œdema of the skin (swelling due to effusion into connective tissue), and hypertrophy (morbid enlargement) of the cellular tissues, known as "elephantiasis."

Impure Water and Mosquitoes.

Prevention.

Prevention consists in removing the sources whereby drinking water is contaminated and in destroying the mosquito.

Yellow Fever. The seat of invasion in yellow fever is the blood. While yellow fever is not a disease commonly met with by the nurse in this part of the country, we will speak of it briefly in this connection. It is a disease which is very rapidly spread by means of a species of mosquito, the stegomyia fasciata. Dr. Carlos Finlay,* of Cuba, in the year 1881, first proclaimed positively that this species of mosquito carried the yellow fever germ, which as yet

* Dr. Finlay died at his home in Havana, Cuba, August 20, 1915, aged 81. He was born in Puerto Principe, Cuba, December 3, 1834. He was educated in Rouen, France. He was graduated in medicine from Jefferson College, Philadelphia, in 1865.

remains undiscovered; but the connection of the mosquito with yellow fever announced by Finlay waited until 1900 for its experimental demonstration at the hands of the yellow fever commission consisting of Drs. Reed, Carroll, Lazear and Agramonte. A number of American physicians had been suspicious of mosquitoes years prior to Finlay's time, having observed their prevalence during yellow fever epidemics. Dr. Rush, in 1793; Dr. Weightman, in 1839; Drs. Wood and Barton, in 1853, all had given voice to this opinion. The experiments of the American workers, Reed and Carroll, and their assistants Agramonte and Lazear, brought to light positive proof of the part the mosquito, stegomyia fasciata, plays in the rise and spread of yellow fever. The yellow fever commission was appointed by the Surgeon General of the United States Army to carry on a work of investigation at Havana, Cuba, in the year 1900. It has been proven through the efforts of this commission that the unknown germ of yellow fever is transmitted from the sick to the well through the bite of just this one type of mosquito and has also made clear the utter futility of attempts at circumscribing the disease by means of disinfectants. These men have successfully demonstrated that *the blood* is the only avenue of escape of the germ and that in no other way than through the

Yellow Fever Commission.

Cause.

How Transmitted.

The Blood Only Avenue of Escape.

agency of stegomyia fasciata can the infected blood be carried and transmitted. Therefore, use of disinfectants must be valueless and destruction of the mosquito, stegomyia fasciata, the only solution of the yellow fever problem. With regard to Carroll and Lazear, authorities tell us that on August 27, 1900, Carroll allowed himself to be bitten by stegomyia fasciata that twelve days before (on the second day of the disease) had bitten a typical case of yellow fever. After an incubation period of three days, Carroll developed a very severe form of the disease. He made an uneventful recovery.

Experiment of Carroll.

Lazear also allowed himself to be bitten by the same species of mosquito, but was not so fortunate as his co-worker, Carroll. Lazear died in a hospital at Washington, D. C., from the effects of yellow fever; a martyr to scientific research.

Death of Lazear.

Major William Crawford Gorgas was serving as health officer at Havana during the work of these men. He immediately began and carried out measures of control based on their discoveries, with the result that by the beginning of 1902 Cuba was free from yellow fever for the first time in centuries.

Work of Gorgas.

In the Southern States and in Mexico, where epidemics of yellow fever occur every year, physicians surround the beds of patients suspected to be developing the disease with a net-

ting to prevent the onslaughts of the mosquitoes. Dr. Walter Wyman, surgeon of the U. S. Marine Hospital, in speaking of the disease in Texas and in Mexico, says that it is necessary to screen the beds of "suspects" because it is not possible to tell until the fifth day whether or not the disease is the "dread yellow variety" which is communicable only *"during the first three days."* Strenuous efforts are being made by the health officers in all parts of Texas and Mexico to exterminate the pestilence-breeding and disease-carrying mosquitoes. Water barrels, which are much used in these places and which form favorite haunts for the mosquitoes, are screened also. All pools and swamps are treated with oil and in some places drained and filled in. These measures were strenuously carried out in the "Canal Zone," Panama, in 1904 by Dr. Gorgas, of Havana fame, who a year before had been promoted to the rank of Colonel and Assistant Surgeon General by special act of Congress. Here for years yellow fever was almost always prevalent. Now the inhabitants enjoy freedom from the disease.

Preventive Measures.

In May, 1920, Major General William Crawford Gorgas, to which rank he had been promoted in 1915, left the United States for Africa to head a sanitary commission of Rockefeller Institute. He had a cerebral

hemorrhage on May 30 and died* June 4, in Queen Alexandria's hospital, London, England, aged sixty-six years, a world-wide loss.

The Bacillus Pestis.

BUBONIC PLAGUE is caused by the bacillus pestis. The bacillus of bubonic plague is a facultative anaërobe. It does not have the power of motion. It does not form spores. Rats become infected with the germs of the disease, and rat fleas that leave the bodies of dead rats carry this infection to man and other animals, particularly ground squirrels. Flies and other insects are believed to carry the infection from infected rats to man, also. It is believed that direct infection from dust or air *seldom if ever occurs.* Spread of the disease may be prevented by killing the rats and their fleas. Good results in the treatment of bubonic plague have been attained through the use of an antitoxin. An epidemic occurred in New Orleans, La., in 1914-1915. The whole city was made rat-proof, disinfected and cleaned up. More than half a million rats were caught, examined and killed. The seat of invasion of this germ is the skin and subcutaneous tissues, the lymphatics, the lungs and the intestinal tract. Authorities teach us that the pneumonic form is the most dangerous and the most readily communicable. All the discharges, in this form, clothing, etc.,

*He was brought back to America for burial August 20, 1920.

must be treated to a hot carbolic acid solution bath, strength 1-20 (5 per cent). Floors and woodwork must be washed daily with a solution of bichloride of mercury 1-1,000. Patients must be rigidly isolated and dead bodies cremated. While this disease is one commonly confined to Eastern countries, it may be carried into our ports on ships infested with rats, mice and other vermin. This germ used to be classed as one that has the power to enter the body through wounds, the alimentary canal, or the respiratory tract. Recently, as already mentioned, these avenues of entrance are considered doubtful. The infection is thrown off in the pus from wounds, in sputum and in discharges from the body, which must be burned at once. When a wound is invaded by the germs, a severe local inflammation results and quickly spreads to the lymphatic glands. Adhere rigidly to personal disinfection at the close of the case, and all through the case.

Supposed Discovery of the Germ.

SMALLPOX. The micro-organism which causes smallpox was reported as discovered by Dr. Wm. T. Councilman, of Harvard College, Boston, Mass., in the early spring of 1904. He made known his discovery during the course of a lecture given in that city on "The Aetiology of Smallpox." He described the germ of smallpox as a "protozoon," represent-

ing the very lowest order of animal life, already described in Chapter II, and therefore quite different from the vegetable micro-organisms common to the majority of communicable diseases. Dr. Councilman is said to have proven that this germ will produce smallpox by his experiments on rabbits and monkeys, but as it is not produced by cultures Koch's circuit is not traced. The smallpox infection is general. It invades the skin, the conjunctiva, the mouth, the oesophageal tract, the rectum, and the blood.

Koch's Circuit Not Proven.

An Air-borne Disease.

Smallpox is one of the air-borne diseases and enters the system through the respiratory tract and may also be introduced through the skin. The disease is so readily communicable that all discharges must at once be burned. The chief factors in the spread of the disease are the secretions from the nose and throat and the desquamating skin, all of which contain the poison. Flies which alight on patients spread the disease. Patients must be isolated and protected by screens about their beds. Great care should be observed to prevent particles of peeling skin from being carried by the air as floating dust. In giving baths the water should contain a disinfectant. Antiseptic washes are used and also inunctions of antiseptic ointments or oils to lessen the danger from desquamation. "Everlasting and eternal

vigilance" must be observed in all diseases where there is desquamation. Formaldehyde vapor is recommended for fumigation after disinfection and cleansing at the close of the case.

A Matter of Precaution.

A lecturer* on "Specific Fevers" when speaking in the writer's presence on the subject of smallpox a few years ago, advised a class of pupil nurses as a matter of precaution to "burn everything but the patient at the close of the case."

The Nurse's Danger.

Preventive treatment in smallpox epidemics consists in the rigid carrying out of vaccination. It is not considered that a nurse who has recently been vaccinated incurs the slightest risk in nursing small pox.

Spores Almost Impossible to Kill.

ANTHRAX. The bacillus of anthrax, a disease of cattle and sheep, is called the bacillus anthracis. It is a facultative anaërobe. It forms spores. It has not the power of motion. Its spores are harder to destroy than those of any other known germ. They are said to resist boiling for half an hour and have been found alive in a five per cent solution of carbolic acid after forty days. A 1-1,000 solution of bichloride of mercury has in some instances failed to kill them in three days.

While anthrax is a disease of cattle and sheep, members of the human family may

* Dr. Robert Saunders Henry, lecturer on Specific Fevers, Thomas Hospital, Charleston, West Virginia, '98 to '02.

acquire it through direct contact with the infected animals or by handling their products. The germ of what is known as "Woolsorters' disease" is the bacillus anthracis. It attacks the lungs of men who have to handle the wool of sheep that have anthrax. Wounds in the skin admit the germs and these set up a local infection called "malignant pustule."

GLANDERS. Another disease of the lower animals is known as glanders. The bacillus malliae is the germ of glanders. It is a facultative anaërobe. It does not possess power of motion. It does not form spores. It is acquired by man in the same way that anthrax is acquired.

MALIGNANT EDEMA. Bacillus of malignant edema is strictly an anaërobe. It does not possess power of motion. It forms spores. The human family become infected through handling soil in gardening should there be any open wounds about the hands. Such wounds should always be carefully cleansed and disinfected.

SUMMARY OF CHAPTER V.

The terms contagious and infectious as formerly used have given place to the more accurate term "communicable."

The specific invading micro-organism of some of the communicable diseases.

Means of transmission—methods of entrance.

Seat of invasion.

Effects—constitutional or local.

Multiplication or extermination of germs.

Cleanliness and fresh air as preventives of diseases termed communicable.

The points demanding most careful attention on the part of the nurse in all communicable diseases. Disinfection, etc.

BACTERIA IN SURGERY.

CHAPTER VI.

SEPSIS, ASEPSIS AND ANTISEPSIS.

In surgical practice the bacteria met with most frequently are the following:

Germs Commonly Encountered.

The Staphylococcus Pyogenes Aureus, the streptococcus pyogenes, the bacilli coli communis, the bacillus tuberculosis and the bacillus tetani.

The Staphylococcus *Pyogenes Aureus, is a facultative anaërobe, water, dust and air are all means by which this micro-organism is distributed. It is found, also, in the mouth, under the finger nails, and in superficial layers of skin. This is the germ most frequently found to be concerned in severe forms of inflammation confined to small areas in which pus is found, described as "acute, suppurative circumscribed inflammation," such as boils, abscesses, etc. While the staphylococcus pyogenes aureus does not *belong to the spore-forming species,* it is very difficult to destroy, resisting to a remarkable degree all means used for its extermination.

The Staphylococcus Pyogenes *Albus and *Citreus. These germs are found in the

* Pyogenes signifies pus-forming; Aureus, golden-yellow.

* Albus means white.

* Citreus, citron-yellow. These colors are assumed when seen in growing cultures.

pus from acute abscesses, but are less virulent than the staphylococcus pyogenes aureus.

*STREPTOCOCCUS PYOGENES. A facultative anaërobe, and one of the most frequent causes of peritonitis after surgical operations (post operative peritonitis) is said to be the germ streptococcus pyogenes. It is found also in puerperal endometritis (inflammation of the mucous membrane lining the uterus after a child is born); in ulcerative endocarditis (inflammation of the membrane lining the heart accompanied by ulceration), and is also believed to be the cause of general septicæmia (general poisoning of the system due to bacteria in the blood).

DIPLOCOCCUS PNEUMONIA. This micro-organism, or germ, is found in empyema (formation of pus in a cavity), and in acute abscesses.

BACILLUS TETANI. Surgeons always fear the bacillus of tetanus in accidental wounds, particularly those which have been exposed to danger of infection from the dust of streets,

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* While the streptococcus pyogenes is a *most dangerous* germ, it is not difficult to destroy, fortunately. Exposure to a temperature of 130° F. for fifteen to thirty minutes or to *boiling* water for the same period is found to kill it outright. Bichloride of mercury solution 1-4,000, lysol or carbolic acid solution, 2½ per cent, *used hot,* and exposure thirty minutes to one hour, is sure to do the work necessary to destroy it.

stables, or cellars. It is not likely to develop in clean, open wounds of surgical operations.

The Cause of Sepsis.

SEPSIS, ASEPSIS AND ANTISEPSIS. Sepsis is the result of the gathering of bacteria into the blood. Bacteria, as we have already said in a previous chapter, is the name given by scientists to the large field or group of vegetable micro-organisms we commonly hear spoken of as "germs" or "microbes."

We have also said that there are special bacteria for special diseases, as for example the "bacillus typhosus" in typhoid fever. In tuberculosis the "bacillus tuberculosis," etc. The shape of the bacteria in many instances giving to it its name, viz.: bacillus, "rod-shaped or pencil-like," spirilla, "twisted or curved," cocci or micro-cocci, "sphere-shaped," or like a ball or marble, with modifications or subdivisions of these shapes as for experimental purposes they are cultivated in gelatinized broth or other liquids, and their varied methods of forming into groups is seen under the miscroscope. These varied groups are spoken of as "clusters," "chains," "twos," "fours," "eights," and so forth. Sometimes the disease in which the germ is first found gives to it its name. The bacteria found in sepsis when seen under cultivation are grouped in "chains," and the name given to them is *streptococcus pyogenes* (chain-like coccus which is pus-forming).

Sepsis Defined.

SEPSIS means poisonous or putrid. Asepsis, free from poison or putrefaction. Antisepsis, against poison or putrefaction. Sepsis is found in general surgery, in gynecological surgery and in obstetrics. But it ought not to be found in any one of them. In these days of aseptic surgery when so much time and thought and expense are given to the preparation of the patient, operating-room, dressings, surgeon's gowns, caps, instruments, etc., so as to render all these, and surgeons, assistants and nurses as well, absolutely free from poison (aseptic) by means of sterilization and antiseptics no one should suffer from so terrible a condition, a condition dreaded by all physicians and nurses.

Sepsis Should Not Occur.

Following the preparation of dressings, bandages, gauze, sponges, etc., the utmost possible vigilance is necessary in order to be sure that all are *kept aseptic* after they have been *made aseptic*. Of what avail is the special process they undergo if the packages containing them are opened and the dressings passed to the surgeon by a nurse or assistant who has not been properly prepared by the free use of soap, hot water, scrub-brush and the after thorough use of antiseptics, especially in "hand cleansing"? Of what use is it to use an aseptic brush, antiseptic solutions and so forth in preparing the area to be operated upon if the nurse

Blunders During Operations.

who uses the solutions has been opening and closing windows and doors, or touching other things not aseptic, and then comes to take part in the work mentioned without first thoroughly scrubbing and sterilizing her arms and hands? It is after just such blunders as these in operating rooms, or in private homes, that trouble with the patient often arises. There is great reason to wonder why trouble does not arise in every case carelessly handled. Frequently the patient comes through the operation well, and for a day or two seems to be doing nicely, then comes a chill, a sudden rise of temperature, an increased pulse rate, the patient is restless and uneasy, and has a worn, anxious expression; other symptoms more or less alarming appear. The physician is hastily summoned, and with a grave face, which he vainly tries to brighten in the patient's presence, he examines the chart, then mutters beneath his breath "*sepsis;*" always a dread word even to physicians and nurses grown old in the work. He removes the bandages and dressings to find abscesses formed about the stitches he had put in with such care, or, worse still, pus oozing from between the stitches. Then comes a hand to hand fight to overcome the effects of the poison and to save human life, which, sad to say, cannot always be accomplished, no

Result of Blunders.

Symptoms.

A Fight for Human Life.

matter how closely the physician's orders are carried out.

How Did It Occur?

In place of a surgical case we may have a case of *obstetrics, perhaps a case in which it has been necessary to use instruments. The nurse in preparing them for the physician's use has not been sufficiently careful, or in some other way something containing the streptococcus pyogenes, the germ of sepsis, has been carried into the puerperal genital tract. Again we have the characteristic symptoms observed in the surgical case, and again the dread word "sepsis," rings in our ears.

Sepsis Cases Becoming Rare.

Glad we are to be able to say that such cases are more rarely encountered as the years go by. A conscientious, well-trained nurse will watch every corner, and will let no source of infection escape her keen eye. She will use all aseptic and antiseptic precautions herself, and she will also guard well her work against

*In most of the best Maternity Hospitals of the present day all personal clothing, as well as bed linen, used for both mother and infant during the first week are sterilized, just as for a surgical case. This applies especially to the gowns, abdominal bandages, perineal pads, diapers, etc. These are put up in packages, separate from those containing gauze for the cord, silk, etc. Each package contains sufficient clothing for one day. After sterilization they are not handled until needed. Infants so cared for are said to be less troubled with skin eruptions, and there are no infections of the cord. Sterilization of articles used for the mother serves as a further protection against sepsis.

any such disasters (or worse) as have already been alluded to.

A nurse who has just been in contact with patients suffering from streptococcus infections, or pus infections of any kind, must never attempt to care for an obstetrical case or a surgical case, even though she has used antiseptic precautions.

The Debt We Owe Lister and Semmelweis.

Surgeons, themselves, as a rule, realize very fully the grave responsibility of a life at stake; but seldom do we meet a careless one. They, as well as the world at large, owe a debt of gratitude to Semmelweis* and Lord Lister* for the discovery of the possibility of the *overthrow of the power of sepsis* through the use of disinfectants.

Sterilization.

STERILIZATION AND DISINFECTION. We often hear the terms sterilization and disinfection used interchangeably as expressive of the same meaning, which, strictly speaking, is not accurate. When we sterilize anything we are supposed completely to destroy the vitality, or life, of all bacteria present, either within, or upon the substance sterilized. The process of sterilization is accomplished by the proper application for a stated period of either chemical agents or heat.

Disinfection.

In order to disinfect anything we do not necessarily destroy all the bacteria present, but

* See history, Chapter I.

only those that are harmful, because of their power to create disease—power to infect—in other words.

Antiseptics. Certain substances used to prevent the growth of bacteria, but which may not *necessarily destroy* them are called antiseptics. An antiseptic does not always possess the power to disinfect, but a disinfectant is always an antiseptic. Normal saline solution is an antiseptic, but it is not a disinfectant.

Germicides. Germicides and disinfectants *are* interchangeable terms because they both possess the power to destroy disease-producing germs.

Deodorants. Deodorants are substances or agents used to destroy offensive odors; they are not of necessity disinfectants, but they may be. Creolin, lysol, formalin and carbolic acid are all both deodorants and disinfectants, while such deodorants as Eau de Cologne and violet extract have no power to disinfect.

VARIOUS CONDITIONS MODIFY THE POWER OF DISINFECTANTS.

Conditions Modifying the Power of Disinfectants. I.—The kind of bacteria we wish to destroy. Some are more difficult to kill or to render powerless to do mischief than others. Spores are found much harder to deal with, as was spoken of in describing their formation, than the bacteria from which they spring.

II.—The number of bacteria to be destroyed. If a large number are present more of the solution is necessary than for a small number. Completely saturate the mass *always,* for whatever number.

III.—The temperature and strength of the solution. *Hot* disinfectants are more effective than warm or cold disinfectants; in fact, *all disinfectants should be used hot.*

IV.—Material with which a solution may come in contact. If some disinfectants come in contact with *organic matter,* they are rendered of little or no value thereby. The writer remembers seeing a pupil nurse sent three times to empty out and prepare anew a disinfectant solution because an assistant *put his soiled* finger into the first two, in order to test the temperature, and was about to make the same blunder a third time when prevented by the whispered admonition of the head nurse. The lesson is plain.

An Assistant's Mistake.

V.—Length of Time Given the Disinfectant to do Good Work. As a rule, too little attention is paid to the matter of teaching pupil nurses the necessity for allowing articles to be disinfected to remain in the solution, or to be exposed to heat, etc., for a sufficient length of time to obtain good, safe results. *Give definite instruction* with regard to *time required*

Instruct Your Nurses.

to disinfect hands, clothing, instruments, and so forth. Such instruction will save trouble many times. (See Chapter VII.)

Hot Air, Steam, Boiling Water.

Hot air, steam or *boiling water,* are all disinfectants or germicides. The value of hot air or dry heat as a disinfectant is limited, as there are so many things which cannot be disinfected by either without being injured. *Moist heat* (steam), is more penetrating than hot air, and mattresses, clothing, and surgical instruments can all be treated by moist heat without sustaining injury. Clothing stained with pus, or fecal matter, should not be disinfected with steam heat, as the stains will be found difficult, if not impossible, to remove afterward.

Boiling water is warranted to destroy all KNOWN BACTERIA AND WITH RARE EXCEPTIONS THEIR SPORES if exposed to its power for a sufficient period, and provided, also, that a sufficient quantity, *at least three times* the bulk of the material containing the bacteria, is used to saturate the mass.

The spores of the bacillus tetanus are, as a rule, killed by exposure to live steam or *boiling* water for ten minutes, but they have been found alive on splinters of wood that had been *boiled* more than a score of years earlier.

The spores of the bacillus anthracis have been found *alive* after boiling for thirty minutes. They have, also, been found *alive* in a

five per cent carbolic acid solution after forty days' immersion and after three days' immersion in 1-1,000 bichloride of mercury.

Definition.

INTERMITTENT STERILIZATION. By intermittent sterilization we mean the exposure of articles to be sterilized to the action of live steam for one hour on three successive days. Certain spores, we have stated, have been known to retain germinating powers after being treated to a bath of boiling water, and the end sought in intermittent sterilization is to destroy all bacteria which may develop from spores after the first or second sterilization. The process is not always necessary, because exposure to live steam for one hour usually kills both bacteria and spores.

Healthy Tissue Aseptic.

In aseptic surgery many consider the use of both heat and chemicals necessary in order to insure freedom from all pathogenic bacteria and their spores. This applies only to the preparation of dressings, sponges and the skin, *except in diseased conditions. "Clean healthy tissue* contains no bacteria." "Wounds in healthy tissue tend to heal spontaneously."

"Antiseptics being all more or less irritant tend to interfere with the healing process."

Infection of Healthy Wounds.

If a healthy wound is properly protected from possible invasion of micro-organisms, the use of antiseptics is unnecessary and may be injurious. Infection may reach the wound in several ways:

I.—Because the room in which the operation is performed is not properly prepared, or if sweeping or dusting is done just when the wound is to be uncovered for dressing. Dust must always be wiped up in sick-rooms where wounds are to be dressed with a cloth wrung out of a disinfectant solution.

Never Dust With a Dry Cloth.

II.—Use of water not sterilized in its container, or not kept closed after sterilization, when it again becomes filled with microorganisms.

III.—If the skin of the patient has not been made aseptic prior to the operation. No matter how cleanly a person may be, the skin, the hair follicles, and sweat glands all harbor bacteria, and if not properly attended to these may invade the wound. (Ordinary *cleanliness* is not "surgical cleanliness.")

IV.—The hands of the surgeon or nurse may cause the trouble.

Responsibility of the Nurse.

V.—Instruments, drainage, the clothing of patient, or operator, or nurse, ligatures, sutures, sponges, dressings, towels, any of which may be infected. The nurse's duty is to guard against danger of infection from whatever source. After careful cleansing, drainage tubes must be boiled for an hour on three successive days and kept between times and until needed for use in a 75% solution of alcohol. Boil again for ten minutes just prior to using.

Disinfect your hands or put on sterilized rubber gloves and insert the sterile gauze packing required by many surgeons and fold the tubing in a sterile towel ready for use when called for. Gauze sponges, dressings, towels, gowns, etc., should be placed in separate packages, plainly marked and exposed to the influence of live steam in a high pressure sterilizer for thirty minutes on three successive days. They must not be opened until they are required for use. Ligatures and sutures should be loosely wound on glass spools and placed in test tubes plugged with sterile cotton before placing in the sterilizer. The cotton plugs, unless made too firm, will permit the entrance of sufficient heat to sterilize the material. Always keep sutures and ligatures in sterile tubes closely plugged when not in use, and place these in tightly closed sterile glass jars. Gauze sponges should have no raw edges exposed. When properly made they are folded upon themselves and all raw edges are turned in.

Be Sure of Your Sponge Count.

A careful nurse never makes a mistake in the number of abdominal sponges she has in use during an operation.

Special Catgut.

Catgut requires much preparation in order to make it safe. Many surgeons prefer to use catgut which is scientifically prepared in large laboratories; this is put up in specially constructed tubes, which are not opened until re-

quired for use. Even these would better be sterilized again prior to the operation.

Disinfection of Field of Operation.—The most up-to-date surgeons in our best hospitals nowadays do not subject their patients to the very vigorous preparations of "the field of operation" which used to be such torture to the weak and nervous. After careful investigation it has been demonstrated that the severe scrubbing, after the cleansing bath and shaving of the parts; the application of irritating solutions of various kinds, "soap poultices," bichloride dressings and what not were practically a waste of time. "They failed to reach the deep skin glands where bacteria lurked unharmed." Some still cling to old methods, but the one most in favor, both at home and abroad, is to paint the field of operation with a five (5%) per cent solution of iodine in fifty (50%) per cent alcohol just before the anaesthetic is given and to cover it with sterile towels until the surgeon is ready to begin his work; then the painting is done a second time. The preliminary full cleansing bath and shaving process are attended to as usual, the night preceding the operation (unless it is an emergency case), but no dressings or bandages are applied, as a rule.

Irritating Solutions, etc., Out of Date.

Other antiseptics must not be used on the skin prior to painting with the iodine, and a

fresh solution must be prepared for each operation. If these precautions are not observed a skin eruption (dermetitis) may arise. If a stronger solution than five per cent is used the same trouble sometimes follows. A one per cent solution of iodine in benzene is used to cleanse the skin in emergency cases where there is not time for the full bath. Then follows the painting with the iodine and alcohol of prescribed strength.

Precautions Used.

No. 1. Hand Disinfection.—*First,* cleanse the hands (including the arms above the elbows) with plenty of antiseptic soap and hot water, using a sterile brush vigorously for ten minutes, especially for the nails, beneath which germs lurk. *Second,* clean the nails thoroughly with a nail knife or file, to remove any bacteria the nail brush may have left behind. *Third,* scrub the hands again, as the nail cleaning process will have deposited particles of dirt containing germs on the hands.

Soak Hands and Arms.

Fourth, soak the hands and arms for several minutes (3 to 5) in a solution containing about twenty grains potassium permanganate to each pint of water, and then in another solution of oxalic acid (saturated solution), soaking the hands for the same length of time. The potassium permanganate is a good germicide, unless it comes in contact with organic matter, and oxalic acid is a still better one; it also

removes from the hands the brown stain of the potassium permanganate. *Fifth, soak the hands* and arms in alcohol, and again in hot sterile water. Dipping the hands and arms in the solutions is of no avail. The alcohol is a further precaution against bacteria, and the sterile water relieves the irritation caused by the vigorous scrubbing and use of strong solutions. During operation use alcohol, bichloride of mercury solution, 1-8,000, and sterile water if necessary for further protection.

Alcohol and Bichloride Preferred.

No. 2. HAND DISINFECTION.—Some surgeons use alcohol, followed by bichloride solution and hot sterile water, applied in the same way as the permanganate and oxalic acid are used after the vigorous scrubbing with brush, soap and water and use of nail knife recommended in No. 1. There are various other methods of hand disinfection.

No. 3. HAND DISINFECTION.—This method has given uniformly good results.

I.—*Five to ten minutes* thorough washing and scrubbing with green soap and hot water, using a sterile nail brush vigorously, especially about the finger nails, and drying with a sterile towel.

II.—Careful cleaning and clipping of nails with nail file and knife.

III.—A second washing of hands with soap and hot water for further cleansing from nail deposits.

IV.—Chloride of lime paste is next well rubbed into hands and nails, and well rinsed off in a soda carbonate solution.

V.—Soaking of hands three to five (3 to 5) minutes in a bichloride of mercury solution 1-4,000, followed by hot sterile water.

During certain operations many surgeons use for the hands a bichloride of mercury solution 1-4,000, if necessary, followed by sterile water, as a precautionary measure. In the most up-to-date hospitals, surgeons and their assistants and the nurses who have charge of the instruments and dressings during surgical operations, are nowadays using face masks as well as rubber gloves. Those who as yet have not adopted the face mask tie several folds of gauze over the mouth; the saliva, even of the most healthy, has been proven to contain pathogenic bacteria. A slight cough may eject the saliva upon the field of operation with disastrous consequences to the patient.

Face Masks and Rubber Gloves.

No. 4. Cleanse the hands, arms and nails as in No. 3, but do not use the bichloride solution, then put on rubber gloves. When rubber gloves are to be worn the bichloride solution must be omitted from the cleansing process, as there is danger of a severe skin eruption

(dermetitis), arising, if after it is used rubber gloves are put on. The use of rubber gloves does away with the danger from the bacteria which come to the surface of the skin when the hands perspire from the use of hot solutions during the progress of the operation.

Thorough Cleansing Required.

To Disinfect Surgeons' Scalpels and Instruments:—First, cleanse instruments and scalpels thoroughly, paying particular attention to all crevices and hollow parts. Wrap the blades of the scalpels in cotton and place in a separate tray above the tray in which you place the other instruments, as scalpels must only be boiled two minutes, to prevent dulling their edges. Place both trays in the sterilizer in which water is boiling (the water should contain a small quantity—2%—of carbonate of soda). Boil all instruments except scalpels or bistouries twenty minutes. Remove from the sterilizer and place *immediately* in a five per cent (5%) solution of carbolic acid, covering the receptacle with a sterile towel, unless the surgeon prefers to use his instruments dry, which many do; in this case they are kept in the sterile receptacle in which they are boiled and covered as quickly as possible. The same process of cleansing and sterilizing should be adopted after an operation; they must be wiped dry with a sterile instrument cloth before returning to the instrument closet.

Watch Your Scalpels.

Cover Instruments Quickly.

The method of sterilizing instruments adopted by some hospitals is to wrap the instruments in a sterile towel after cleansing thoroughly, and then to expose them to the influence of live steam for a stated period; about thirty minutes.

Rubber Gloves.

To Disinfect Rubber Gloves. Wash on both sides with green soap and then in sterile water. The gloves may be turned by immersing in a solution until each finger is filled with water. They may be disinfected in a disinfectant solution in the same way and "floated on" to the hands by holding the hand under the solution as each glove is drawn on while the fingers are inflated with the solution. Rubber gloves may also be cleansed, thoroughly dried, powdered with boracic acid or other powder, wrapped in gauze or a sterile towel and sterilized with the dressings or instruments in a high pressure sterilizer. Time required for sterilization, one hour. Rubber gloves should be cleansed, disinfected, thoroughly dried, powdered and put away carefully after each case.

Use of Soda Carbonate.

To Disinfect Sputa and Sputa Cups:—Pour into the cups sufficient hot five per cent (5%) carbolic acid solution to saturate the contents of the cup. Add a small quantity of carbonate of soda, 5% solution (common washing soda), to loosen the sputa from the sides and

bottom of the cup; *cover* and allow to stand until cold before emptying, then cleanse thoroughly. The cups should be well scrubbed and boiled once a day in a soda-carbonate solution, 5%, particularly the sputa cups of tuberculosis patients.

Boil Sputa Cups.

To Disinfect Clothing, Beds, Bedding and Furniture:—Personal clothing, towels and bed linen used in the care of communicable diseases must be soaked for two or more hours in a proper disinfectant solution (carbolic acid, sol. five per cent (5%) is good), and then thoroughly washed. Dry in the outdoor air and sunshine. Mattresses and pillows should be exposed to the influence of live steam for a sufficient length of time to do good work. When there is no apparatus for the steaming process, wash the surfaces of pillows and mattresses with a disinfectant solution named in this paragraph, turn over the foot-boards of the beds in rooms or wards to be fumigated, so that the substance used for fumigation may reach them *from all sides.* To complete the process, put them out in the fresh air and sunshine for twenty-four to forty-eight hours. Mattresses stained with typhoid fever defecations or hemorrhages would better be burned.

Outdoor Air in Disinfection.

Exposure from all Sides.

Beds, windows, walls, floors, woodwork and all pieces of furniture first must be cleansed with brush, soap and hot water and then washed

Leave Bureau and Other Drawers Open.

with the disinfectant solution. Bureau and stand drawers, closets and closet shelves should be treated in a similar way, *and left open* for fumigation. The thorough cleansing with soap and water must be again repeated *after fumigation*. If floor rugs are used they should be exposed to live steam or washed off with the solution, and *both sides* exposed to the fumes of formaldehyde or other substance just as recommended for mattresses. Then they should be hung up and well beaten in the open air, and left there for twenty-four to forty-eight hours also.

To Disinfect Rubber Sheets:—First, wash clean in hot water with soap and brush, rinse in clear water and soak one hour in carbolic acid five per cent (5%) solution, or other good solution. Wipe dry and hang out in the fresh air and sunlight to remove any odor than that of rubber. Sheeting with the rubber preparation on either side (reversible), is the best and safest in nursing communicable diseases. The disinfecting can be more thoroughly accomplished, and the sheets *look safe*. This sheeting makes a good covering for all vessels used for evacuations, etc., to be disinfected.

Removal of Odors.

Reversible Rubber Sheeting.

SUMMARY OF CHAPTER VI.

Bacteria in surgery. Cases in which they are found.

Sepsis, its cause, the germ found in sepsis. Why there should be no cases of sepsis in the present age. Why sepsis is so much to be dreaded.

The "everlasting and eternal vigilance" necessary in surgical work and nursing. The dangers to be guarded against. What may come of blunders in surgery and in obstetrics.

Responsibility recognized by most surgeons as too great to be trifled with.

The nurse's responsibility should be ever uppermost in her thoughts.

Sterilization. Disinfection. Antiseptics. Germicides. Deodorants.

Conditions which may lessen the power of disinfectants.

Heat as a germicide. Intermittent sterilization.

Aseptic surgery. The precautions necessary to prevent infection from reaching healthy tissues.

CHAPTER VII.

SOLUTIONS, THEIR USES AND PREPARATION.

IODIN SOLUTION:—Harrington's solution of iodin is an antiseptic rapidly growing in popular favor. Strength used, 1-100 and 1-500. This solution is believed by many to be the best antiseptic now in use for any purpose.

Iodin Tincture.

In the form of tincture of iodin this antiseptic is used to cauterize ulcers of various forms and also as an application or dressing in suppurating and other wounds. In 1-1,000 solution it is sometimes used as a disinfectant for the hands. A solution of commercial (household) ammonia must be used after the iodin to remove the stain from the skin. In five per cent solution in fifty per cent alcohol it is used to disinfect "the field of operation" in surgical cases. In cases of emergency a one per cent solution is used in benzine to cleanse the field of operation if there is not time to bathe the patient before painting with the five per cent solution in alcohol.

Cases in Which It Is Unreliable.

CARBOLIC ACID SOLUTION AS A DISINFECTANT:—Carbolic acid solution may be safely used for the disinfection of personal clothing, bedding, excreta, surgical instruments and appliances. It cannot be relied upon to destroy *spores*, and therefore should not be used

as a disinfectant in tetanus, anthrax, malignant œdema, or in any disease due to invasion of spore-forming bacteria. To disinfect linen, one per cent strength solution is sufficiently strong to destroy the germs of cholera, typhoid fever, diphtheria and erysipelas if used *hot* in sufficient quantity, and allowed to stand an hour, so as to completely saturate the material to be disinfected. It will not injure furniture or woodwork if used in this strength.

A five per cent (1-20) solution is necessary in surgical practice, in order to be reliable. Fifty-one drams of liquid carbolic acid dissolved in each gallon of water makes a five per cent solution. Pour boiling water over the carbolic acid and *mix* thoroughly. To make a small quantity of a five per cent (5%) sol. carbolic acid (1-20) add one dram of the liquid to nineteen drams of water. (See table at close of Chapter VII. for number of grains to each pint.)

Bichloride of Mercury (also called *Mercuric Chlorid*) solution will destroy all forms of bacteria and their spores. Strength 1-500 required for spore-forming bacteria—exposure one hour. Bichloride of mercury is *not reliable* for the disinfection of excreta, sputum or pus, because of its power to unite with albuminous matter, which protects the substance and prevents the solution from pene-

Where It Fails.

trating the mass. It is a good disinfectant for linen, etc., which is not stained with fecal matter or pus, strength, 1-1,000, *used hot*. It is also used in hand disinfection and as a wet pack or dressing in various forms of inflammation. It ruins instruments or anything in the shape of metals and is injurious to fine woodwork or polished surfaces.

In making up bichloride of mercury solutions, tablets containing seven and a half grains are often used. One of these tablets added to one pint of water makes a 1-1,000 solution. One to a quart a 1-2,000 solution; 1-1,000 is the strongest solution used for almost any purpose. Water is added to obtain the weaker solutions generally used. For example, if you have a quart of 1-1,000 solution prepared and the doctor asks for three quarts of 1-4,000 solution, add three quarts of warm sterile water to your quart of 1-1,000 solution, and you will have the desired strength. If only a small quantity, say one pint of the solution 1-4,000 is needed, take four ounces of the 1-1,000 solution and add to it twelve ounces of water of the required temperature. In using the bichloride of mercury powder (corrosive sublimate), dissolve seven and one-fourth grains (grs. 7¼) in each pint of water. Nurses must not forget that it is a strong corrosive poison and must never be carelessly left about wards,

private rooms or bathrooms, either in tablet form or in solution. Many terrible accidents have been caused by failure to remember this injunction.

SUBLIMINE, which is another preparation of mercury, called ethylenediamin-sulphate of mercury, is used for all purposes in which bichloride of mercury solutions are used. It is considered by some to be less irritating than bichloride of mercury, and alcohol to remove oily substances from the skin prior to its use as a disinfectant is unnecessary. Strength of solutions from 1-10,000 up to 1-300.

PEROXIDE OF HYDROGEN (Hydrogen Dioxide), also called "dioxygen," is considered by many surgeons to have no equal either for safety or efficiency in treating cavities or surfaces secreting pus. This preparation must be kept tightly corked, as it will otherwise deteriorate in value very rapidly, and in a cool, dark place; heat and light spoil the preparation.

Keep in a Cool Dark Place.

INTESTINAL EVACUATIONS may be safely disinfected by pouring upon them three times their quantity of *boiling water*—be sure that it *is* boiling. Cover for one hour before disposing of them. *Milk of lime* made from freshly slaked lime is also a safe, cheap disinfectant for excreta. It should remain in contact with the evacuation for two hours. *Freshly slaked lime* must be used in preparing this solution. To

Keep Your Solutions Fresh.

Give Time for Good Work.

slake the lime, pour one pint of water over two pounds of lime. When dissolved mix thoroughly. This preparation is also called "hydrate of lime." To make the "milk of lime" solution, use one pound of hydrate of lime to eight pints of water. Contact with the air spoils this solution, renders it inert, and for this reason it should be made anew every two days and kept closely covered.

Prepare Frequently.

LYSOL is a good antiseptic, especially so as it is non-irritant. It can be used to disinfect almost everything in the sick-room.

Wide Range of Usefulness.

It is used also for irrigation purposes; for disinfection of skin prior to operations; for hand disinfection, etc. Usually a two per cent solution is required. When using the liquid lysol a two per cent solution can be made by dissolving two and one-half fluid ounces of the drug in one gallon of water. For dressings prior to operation, one-half per cent solution is used. (For number of grains required in making up solutions, see table.) Tricresol, solutol and solveol are among the most valuable disinfectants of the present day. They all destroy spores and are not open to the objection raised against bichloride of mercury with regard to albuminous substances. They belong to the same family as lysol and are known as the creosols. Tricresol is accounted as the best disinfectant of the group, solutol, solveol and lysol

following in value in the order named. 1 to 5% solutions are required in order to be effectual.

Strength of Solution.

CREOLIN is another antiseptic used as a disinfectant for the hands, and also for the purpose of irrigation. A five per cent solution is sufficiently strong, as a rule.

Silver Nitrate.

SILVER NITRATE. Silver nitrate is a caustic poison and is very valuable as a germicide. It is used more especially in what is known as Credé's method for preventing gonorrheal infection in the eyes of the newly-born, when there is suspicion of danger of this disease in either parent. A two* (2) per cent solution is dropped into the eyes (*one drop in each eye*), and then immediately followed by a normal saline douche with a cotton swab.

Usefulness Limited.

POTASSIUM PERMANGANATE is a fairly good disinfectant, but its application is limited, because its action is so quickly rendered inert by contact with organic matter. It also stains a yellowish brown any object which it touches, and the stain requires the application of an acid to remove. It is used quite extensively as a deodorant in offensive wounds, for hand disinfection and to irrigate cavities. Sixteen to twenty grains of the potassium permanganate crystals to each pint of water is the strength of the solution generally used. Oxalic acid (a saturated solution) is frequently used to re-

Weak Points.

* Many obstetricians use 1% solution.

move the stain of potassium permanganate. It is considered to be a more powerful germicide than permanganate of potassium, but it is decidedly irritant in its effects.

Definition.

NORMAL SALT SOLUTION is a solution of sodium chloride in distilled water. As a douche and enema it is well known, and as a continuous irrigation for stimulating purposes by "the drop method." It is also used in intravenous, subcutaneous and rectal injections, for its stimulating effect after hemorrhage in various diseases; in shock during or after surgical operations; in toxemia from any cause. A pint of the solution is frequently given by rectal injection an hour or two before a surgical operation, as its use serves to lessen the possibility of shock, and also *assists in preventing the thirst from which patients so often suffer after surgical operations.* 0.6 per cent is the strength used. The solution is made by dissolving one dram of common salt in each pint of hot water. Sterilize in its container before using, except where used as a rectal injection, when sterilization is not necessary. When used intravenously, or subcutaneously, it must, of course, *always be sterilized.** The intravenous injections are

Wide Range of Usefulness.

*Sterilize the syringe, canula, suture, thermometer for testing the temperature of the solution (which should be 115° to 120° F.), scissors, and everything in the shape of instruments by boiling in soda carbonate solution. For subcutaneous and intravenous injections, thoroughly scrub and sterilize the area to be used.

never given by the nurse, as it is a method confined to the physician alone. It is used during operations very often, or immediately after operations, when there has been much loss of blood, or where the patient is suffering from shock, in order to "furnish sufficient fluid to suspend the remaining red blood cells for circulation through the system, and to restore a normal amount of circulating fluid for the heart and arteries to act upon." For wet dressings, packs, purposes of irrigation and for soaking of wounds or incisions after surgical operation in septic and other cases, no better solution than normal saline has yet been discovered. As an antiseptic, it has few equals.

When Preparing for an Operation the nurse can make up a salt solution containing two ounces of common salt to one pint of hot water; sterilize the solution by boiling fifteen to twenty minutes, *after filtering,* in a *tightly-closed sterile* jar. One dram of this solution added to each pint of sterile water is the strength required for all injections necessary when the patient is suffering from shock, exhaustion, or other causes in which normal salt is called for. It should be made anew for each operation. Or, small tubes containing two drams of common salt may be sterilized by the intermittent method (one hour each day on three successive days). The contents of one

tube dissolved in one quart of *boiling filtered water* gives the physiological or normal strength solution. Cool to proper temperature. The saturated solution contains eleven and one-half (11½) ounces of salt dissolved in *one quart* of boiling water. Sterilize in its container. Use one ounce to a pint of water for "normal" strength.

FORMALIN SOLUTION. A four per cent solution of formalin is considered to be as effective as bichloride of mercury solution 1-1,000, or as carbolic acid solution 1-20 (5%). Formalin contains formaldehyde forty per cent and wood-alcohol ten per cent. Unlike bichloride of mercury it does not unite with albuminous substances in solution, but it *destroys iron, steel or other metal* quite as effectually. The four per cent solution is prepared by adding forty-one-drams to each gallon of water. It destroys spores and can be used safely, also, to disinfect excreta, urine, pus, etc.

Strong and Weak Points.

BORACIC ACID is a mild, non-irritating antiseptic used freely in irrigation and in surgery of the eye and ear. Many surgeons use a saturated solution; others prefer a solution of one dram to each pint of water. It is dissolved by pouring boiling water over the acid powder. It does not dissolve readily in warm water. In fact it would better be boiled. In making the saturated solution, it has been found that only

Boil the Solution.

about eighteen grains of the powder to each ounce of water is soluble in water alone.

THE AMERICAN STANDARD. A solution known as the "American Standard" is made by dissolving six ounces of *chloride of lime in* one gallon of water. It is said to be valuable in the disinfection of excreta. Chloride of lime in order to be reliable must be purchased of a reliable manufacturer.

Reliability.

THIERSCH'S SOLUTION. In the preparation of this solution, which is often used as an antiseptic for purposes of irrigation, add one and a half ounces of boracic acid and two drams of salicylic acid to one gallon of water. Dissolve the acids in *hot water* and *sterilize* before using.

BALSAM OF PERU. A five to ten per cent solution of balsam of Peru is an antiseptic solution frequently used in dressing burns and other wounds. The balsam is combined with castor oil or glycerine as a base. Balsam of Peru, five per cent, and castor oil ninety-five per cent, is the common formula.

A Dressing for Burns.

These are a few of the best drugs for antiseptic and disinfectant purposes now in use. New drugs for the same uses are being discovered every year.

STERILE WATER. As sterile water alone is so frequently used in aseptic surgery, its preparation should be understood even by nurses just entering the work. The water should first

be filtered and then boiled in vessels* which have also been made thoroughly clean by washing and soaking in an antiseptic solution, or better still, *by boiling*. *Distilled water* ought to be aseptic, but as those who distill it are apt to handle it carelessly, nurses are advised to *boil even distilled water* before using it for aseptic surgery.

FILTERED WATER.

FILTERED WATER is not considered safe to use for drinking or surgical purposes without sterilizing. The parasitic bacteria filter through any ordinary filtering apparatus, the process of filtration only ridding the water of other impurities and making it transparent. A system of sand filtration is in use in many cities. By means of the sand the parasitic bacteria are held in abeyance until destroyed by the saprophytic.

Sand Filtration Only Safe Method.

ALCOHOL is used in skin sterilization for the purpose of removing oily substances which prevent the penetration of some other disinfectants; for hardening the skin and "fixing" bacteria therein in hand disinfection, in certain staining of culture methods, and also combined with ether, tannin, etc., it is used for

* Filtered water, distilled water and salt solutions are preferably sterilized in their containers and *kept therein tightly closed* until used.

the same purpose. Ether is used for the same purposes.

SULPHUR DIOXIDE FUMIGATION.

To Fumigate With Sulphur.

To use sulphur for fumigation, take (4) four pounds of rock sulphur (brimstone) for each one thousand cubic feet of air space. All apertures and crevices about transoms, doors or windows, etc., must be well packed with damp absorbent cotton, or batting, or strips of old muslin, to prevent the escape of gas. Paste paper over openings of grates or registers, key holes and speaking tubes. Place an agate-ware, or other metal basin or tub, *half-filled with boiling water* upon a firm foundation made of several bricks built near the center of the apartment. *Moisture is always necessary* during the process of fumigation when using sulphur dioxide. Have the required amount of sulphur on top of some paper in an iron kettle sitting in the basin or tub of water. Pour over the sulphur a few ounces of alcohol. Set fire to the outer edge of the paper and leave the room quickly, as the fumes of gas from sulphur are dangerous to inspire.* Close and lock the doors. Pack all crevices at top, sides and bottom and paste paper over keyholes. Keep the

Danger from Inhaling.

* The writer remembers an instance in which a nurse was almost suffocated by inhaling sulphur gas. She thoughtlessly stepped back into the room for a forgotten article, and was almost overcome when rescued.

room closed for twenty-four hours, then open up the doors and windows and ventilate thoroughly. Floors, woodwork, etc., should then be cleansed thoroughly with soap and water, after all dust is wiped up with a cloth wrung out of carbolic acid solution (5%) five per cent. Sulphur fumigation is more reliable than any other in destroying rats and mice, fleas, pediculi, bed-bugs, etc.

FORMALDEHYDE FUMIGATION.

Advantages of Formaldehyde.

FORMALDEHYDE is more reliable for fumigation than sulphur. It is a gas made by burning methyl alcohol, commonly called wood-alcohol, in a specially constructed lamp. One and a half pints of alcohol are required for each one thousand cubic feet of air space. The process of converting this amount of alcohol into formaldehyde gas or vapor takes less than two hours, and the rooms or wards are ready for free ventilation at the expiration of twelve hours. Observe the same method of packing crevices of doors, windows, transoms, etc., and of closing grate openings and key holes as described in sulphur fumigation.

In some hospitals, potassium permanganate crystals are combined with formalin solution in order to liberate gas more readily and rapidly. The liquid formalin is poured over

the crystals.* It is said to increase the germicidal properties of the solution. Place the vessel containing the potassium permanganate in another vessel containing a quantity of boiling water before pouring in the formalin solution, as a good deal of heat forms when the gas is generated. Formaldehyde and sulphur dioxide tapers are used with good result, also. A wet sheet or other moisture must be present in the room or ward to be disinfected when using these tapers. Semisolid formaldehyde is a preparation recommended by many. A very simple, specially constructed lamp is used for generating the gas which is liberated very rapidly. Moisture in the room or ward during its use is believed to be unnecessary; the preparation itself is moist. It sometimes dries out, however, and then water must be added.

Some Lamps Unsatisfactory.

As so many formaldehyde lamps are unreliable, some have found it more satisfactory to use formalin solution, which contains forty per cent of formaldehyde. The formalin is boiled in a special apparatus and the gas passed into the room to be fumigated by means of a tube inserted through a key-hole or other small

* For a room fifteen feet square, five ounces of permanganate crystals and twenty ounces of formalin solution are used. Solid commercial formalin is sometimes used with permanganate crystals, using six ounces of each and one pint of boiling water for each 1,000 cubic feet of air space.

opening. One gallon of the preparation will supply sufficient gas to purify about twelve hundred cubic feet of air space.

THE SHEET METHOD OF FORMALDEHYDE FUMIGATION.

After packing all crevices in the room or ward to be fumigated, and opening up all closet doors, stand drawers, etc., place a dry sheet in a pail and over it pour one pint of liquid formaldehyde for every one thousand (1,000) cubic feet of air space. Quickly spread the sheet over a line previously stretched across the room. Close and pack the crevices around door frames and transoms. It is asserted that the liberation of the fumes all at once accomplishes the work of disinfection more thoroughly than when they are liberated slowly and diluted with air. Liquid commercial ammonia sprinkled about a room after formaldehyde fumigation will remove or neutralize the odor remaining in the room.

Ammonia Will Remove Odor.

TABLE FOR PREPARATION OF SOLUTIONS.

Using as a basis 7800 grains to the pint.
From "Hospital Formulary."

To Prepare One Pint of a Solution.

Required to contain of a certain substance.

Per cent,	Or	Take of the substance the below stated amount in grains with enough water to make one pint.	
1/100 per cent	1 in 10,000....grains	0.73	(¾)
1/50 per cent	1 in 5,000....grains	1.46	(1½)
1/40 per cent	1 in 4,000....grains	1.83	(1¾)
1/30 per cent	1 in 3,000....grains	2.44	(2½)
1/25 per cent	1 in 2,500....grains	2.92	(3)
1/20 per cent	1 in 2,000....grains	3.65	(3¾)
1/15 per cent	1 in 1,500....grains	4.87	(4¾)
1/10 per cent	1 in 1,000....grains	7.30	(7¼)
1/5 per cent	1 in 500....grains	14.60	(14½)
1/4 per cent	1 in 400....grains	18.25	(18¼)
1/3 per cent	1 in 300....grains	24.33	(24¼)
1/2 per cent	1 in 200....grains	36.50	(36½)
1 per cent	1 in 100....grains	73.00	(73)
1 1/3 per cent	1 in 75....grains	97.33	(97)
2 per cent	1 in 50....grains	146.00	(146)
2½ per cent	1 in 40....grains	182.50	(180)
3 per cent	1 in 33⅓..grains	219.00	(219)
4 per cent	1 in 25....grains	292.00	(292)
5 per cent	1 in 20....grains	365.00	(365)
10 per cent	1 in 10....grains	730.00	(730)
20 per cent	1 in 5....grains	1460.00	(1460)
25 per cent	1 in 4....grains	1825.00	(1825)
50 per cent	1 in 2....grains	3650.00	(3650)

The following simple method of computing the amount of a liquid drug to be used may be found useful when preparing solutions for purposes in which absolute accuracy is not necessary.

One pint, liquid measure, contains seventy-six hundred and eighty (7,680) minims—(℥) 16 × (ʒ) 8 × (m) 60 = (m) 7,680—.

Multiply the number of minims by the per cent solution required and the result gained will be the amount of drug in *minims* for each pint of solution. Divide this sum by sixty (60), the number of minims in a dram, and you will have the quantity to be used in *drams*.

Example.—To make one pint (OI) of a five per cent solution:

$7680 \times .05 = 384.00 \div 60 = 6.40$, or about six and a quarter (6¼) drams of the drug to each pint of water.

For a two per cent solution proceed as before: $7680 \times .02 = 153.60 \div 60 = 2.56$, or about two and a half (2½) drams to each pint of water.

SUMMARY OF CHAPTER VII.

Harrington's Solution—Strength used.

Carbolic Acid Solution—its value as a disinfectant. Its preparation and uses. Its uncertainty in destroying spores.

Bichloride of Mercury Solution—preparation and uses. Its power to unite with albuminous substances.

Use and care of Peroxide of Hydrogen.

Safe method of disinfecting excreta. The preparation of lime for such purposes.

Lysol and Creolin as safe antiseptics.

Advantages and disadvantages of Potassium

Permanganate as a disinfectant. Oxalic Acid in comparison.

Value of Normal Salt Solution. Its preparation, when and how used.

How Formalin may be as effective as bichloride of mercury, or carbolic acid.

Boracic Acid, mild, non-irritating, much used for the purpose of irrigation.

American Standard and Thiersch's Solution —their composition and uses.

Silver Nitrate Solution.

Balsam of Peru combined with an oil one of the best dressings for burns.

Sterile Water—process of sterilization. Distilled water. Filtered water not used without sterilizing in aseptic surgery.

Alcohol: its uses in disinfection.

Fumigation: sulphur, formaldehyde, formalin.

Table for preparation of solutions.

CHAPTER VIII.

Hygienic Precautions Against Bacterial Invasion.

Result of Neglected Hygienic Laws.

Neglect of the laws of hygiene frequently brings upon the human structure troubles which so weaken its various organs and systems that access of bacteria and development of their poisons therein becomes an easy matter. It seems opportune, therefore, to add a few thoughts along hygienic lines.

Nurses, perhaps more than any other class of women, should not only understand but obey the laws of Nature as revealed to us in the study of hygiene. We are so often questioned by sick ones entrusted to our care as to why certain ills have come into their lives. Too often they suffer from diseases of bacterial origin brought upon themselves through neglect or ignorance of hygienic laws. While it is not within the province of the nurse to take the place of the physician, whose duty it is to explain this painful truth to his patient, she can very often afterward help the sufferer by suggestion, advice and example, to guard against future troubles.

Hygiene Defined.

In the first place, then, what do we mean by hygiene? Hygiene is that branch of science which teaches us how to keep healthy. In by-

gone years, so-called civilization and the accompanying customs of the day laid so many restrictions upon women that it was impossible to follow fashion's dictates and be healthy at one and the same time. Young girls were put into tight corsets, French-heeled shoes, etc., when scarcely beyond babyhood; at any rate, before they were fairly in their teens and while they should still have been at play, a thing quite out of the question for the poor little martyrs arrayed in such outlandish costumes. In fact, at the time when foolish mothers allowed themselves to follow fashion's whims and so torture their young daughters, for half-grown girls to romp and play games was considered a social outrage and if young women were to attempt to join in outdoor sports the offense was rated as about next door neighbor to *criminal*. While there may be, and probably are, many who still cling to such erroneous and silly notions, the day has pretty well gone by when established fashions are so directly opposed to the laws of health. Woman now-a-days has just as good opportunities to be healthy as has her brother man. In this age young girls and young women may join with members of the "sterner sex" in games of tennis, golf and croquet without being considered "Tom boys" or unladylike. They learn to swim and to row, to climb to the hilltops, to ride horseback, to take calisthenic

Dame Fashion and Hygiene.

Society's Restrictions.

Outdoor Games No Longer Tabooed.

exercises, to go corsetless if they want to, and to wear skirts whose trains are not an impediment to long, brisk walks in God's pure air and sunshine, all without danger of being called or thought of as either immodest or ahead of the age, and therefore objects for contempt.

God's World.

In our work as nurses so much of our everyday duty lies within doors and quite often caring for those suffering from communicable diseases, that we are apt to become careless or forgetful of the laws which keep us healthy, the principal and most important ones of which are the daily bath, fresh out-of-door air and sunshine and exercise, also sufficient rest and sleep and proper food taken at regular intervals. Without obedience to these laws at the right time and in the right way the nurse cannot satisfactorily fulfill her duty to those the physician entrusts to her care. If she attempts it she soon becomes a physical or mental wreck; sometimes both. The average length of time the conscientious nurse is able to remain in active service as care-taker of the sick is said to be ten to fifteen years. The time must of necessity be much shorter if her health is neglected. This does not by any means signify that we may ever *shirk duty*. Oh, no! There are frequently times of emergency when the nurse, especially the nurse in

Hygiene and Length of Days.

Duty Toward Our Neighbor.

private work, finds it impossible to have her hours "off duty." So often there is no one in the home who is sufficiently experienced in the care of the sick to be trusted to relieve her even for a few hours of much needed rest. If the expense of a second trained nurse cannot be afforded, then the path of duty is obvious. These hours of danger, as a rule, do not last through many days. Then we must again take up our "sponge" and "plunge" baths, our brisk walks in the fresh air and sunshine more rigorously than ever, and so regain our lost tone.

The Laborer is Worthy.

Let us decide right in the beginning as we enter nursing ranks to divide our time of recreation in cultivating all the aids to health and usefulness (not neglecting the mind), and so prolong the "length of days" we shall spend in pursuit of our high and noble calling. High and noble indeed to those who enter the work in the right spirit. Not for the sake alone of the money in it,* although the financial side of the question is important, "surely the laborer is worthy of his hire," and be assured that to

* The writer once had the misfortune to hear a pupil nurse, who had been rebuked for neglect of duty, make this remark: "I don't care how I get through my work in training school. What I am thinking of is the $25 a week I am going to make when I am out for myself." Girls, do not enter the field in such a spirit! The place for such nurses is outside the ranks with the nurse *gossip* and with the nurses who cannot control temper.

the "worthy" are always given the fruits of their labor with all kindly appreciation. But let us remember, also, that there is an inborn love of the work paramount in the heart of every nurse who ever becomes in any true sense of the word *worthy* and a success. Such nurses enter the training-school with heart and soul and mind aglow, with hands ready and willing accurately to perform the most trivial or the most difficult tasks with equal care and promptness. Physicians' orders are carried out promptly and accurately and are "charted" neatly and concisely. At the expiration of the case, while in hospital service each chart is filed away with other hospital records. In private practice, these charts are the property of the physician in charge, and are given to him at the close of the case. These nurses never forget that the patient's chart is a history of the case to which at some future time the physician may need to refer; therefore, every symptom is observed carefully and is recorded faithfully. Their patients always look well cared for; their hair, teeth, tongue, finger-nails and all parts of the body are immaculate; their beds dainty and sweet, and every square inch of the sick rooms or wards over which they have charge is as *neat* and *clean* and *trim* as human hands and *observant eyes can* make it. Use of solutions in communicable diseases is never forgot-

The Successful Nurses.

Who Owns Patient's Chart?

ten. These are the nurses who despise gossip, scorn deceit and all petty meanness, and who realize that personal responsibility is attached as a primary link in the chain of "qualifications of the good nurse." This realization keeps them ever on the alert to add to this primary link all the others necessary to make them not only *good nurses,* but the *best* nurses possible.

Our Duty to Ourselves.

While realizing our duty towards others, do not let us forget that we owe a duty to ourselves also; that we are responsible to God for our own health. There are broken-down nurses in the world today who ought still to be in active service, but whose condition, through *mistaken ideas of duty,* renders them a burden to themselves and to others. Unselfishness is a virtue, but remember also that "self-preservation is the first law of Nature."

Nature's Gifts.

A Healthy Muscular System.—We are taught when studying the muscular system that Nature gives to each individual about the same kind and amount of muscle; that the difference in strength as seen in different people is due in part to the manner in which they are taken care of, used, disused or abused. All of our organs must have proper exercise in order to be kept healthy, and in order, also, that we get from them that service for which they were intended.

Results of Inactivity.

If we do not use our brains in study while we are young they become inactive and we

grow dull and stupid. In later life we awaken to the fact that there are a great many things we would like to know which we do not know, and we find it a much more difficult task to get our brains to act as we desire them to do than it used to be. Study then becomes a burden rather than a pleasure. In the same way, if we do not exercise the voluntary muscles (those muscles which our will controls) sufficiently, they become wasted and soft and flabby, and we feel the effects of their disuse in the involuntary muscles (those muscles over which our will has not control). The heart does not do its best work, the organs of respiration and of digestion and of excretion, etc., are impaired, and the whole structure is apt to suffer.

Results of Overwork.

On the other hand, if the voluntary muscles are abused by over-exercise and insufficient rest we have other evils to contend against. They wear out faster than Nature can supply the new material with which to rebuild them, and we have again the weak, flabby voluntary muscles, and suffering to endure, also, from a weakened condition of the involuntary. All of these things *increase our chances for bacterial invasion.*

Walking Develops the Muscles.

EXERCISE.—Proper muscular exercise, then, is necessary if we would preserve our health. Muscular development of the arms is often very noticeable in nurses who give massage treat-

ment. Good, brisk walks in the open air are conducive to the development of all the muscles of the human structure. When walking do not drag along as if not quite sure what your limbs were given you for. It is necessary to walk briskly in order to keep the circulation just right. Keep your head erect; breathe deeply; your shoulders well thrown back to give the inspired air a chance to expand the lungs and keep them in good working trim. Narrow-chested people become such very often because they neglect to carry themselves erect and "square their shoulders" when they stand or walk. Narrow-chested people *court tuberculosis.* To walk several miles a day is necessary for those whose occupations keep them indoors most of the time.

How to Walk.

How to Dress.

Dress.—There is nothing more hygienic in the way of dress than the nurses' uniform, but it was never designed for street wear. It was designed to protect the *sick from bacteria so frequently carried to them in the woolen dresses,* as well as by the soiled hands, of those who used to care for them, and who knew nothing of the laws of hygiene as trained nurses understand them today.

Keep the Uniform Sacred.

In some cities nurses seem to be given to the habit of going about the streets and on street cars in their uniforms when out for a "constitutional." This practice, if they but stop to

think about it, must impress them as all wrong. We can never tell just where we may encounter a communicable disease, just as likely on the street cars as anywhere else. How dreadful to carry its germs back to some poor sufferer with already enough to bear! Let our uniform then be sacred to the sick-room alone, *but let us always wear it there.* When one *sees* a nurse *on duty* wearing *rings, bracelets, fancy collar and pin,* one stands aghast!

Jewelry and Fancy Collars Not Uniform.

Dress Sensibly.

Have a street dress which is simply but tastefully made and quickly donned. Wear hygienic waists, and skirts suspended from the shoulders rather than from the hips. Wear sensible-looking, neat hats. Nothing is much more unprofessional than a nurse in a hat on the "flower garden" order, or who is adorned with neck chains, rings, "bangle" bracelets, and so forth, whose skirts sweep the streets and gather up dust and bacteria as they sweep. When it comes to exercising in garments that constrict the chest and abdominal muscles, it is quite out of the question. How can the abdominal or pelvic organs remain healthy when thrown into unnatural positions by pressure of tight corsets, waist bands or dragging skirts? How can the nurse who goes out in cold or wet weather only half clad expect to be healthy? Any young woman is deserving of censure who goes out in unseasonable weather

in a waist and skirt on the spider-web order over gossamer underclothing; who wears also flimsy, low-cut shoes and the thinnest of hosiery; yet we try to excuse her on the plea of "poor judgment" or "a lack of common sense," but for *the nurse there should be no excuse.* In her daily avocation she comes in contact too many times with the fruits of just such errors in judgment. She sees in all their sadness the evils brought upon the human frame by just such indiscretions. The cold that developed after exposure to the elements; the cough that never got well; the development of tuberculosis; the wasted pain-racked frame, all these are object lessons too familiar ever to be lightly overlooked or forgotten. It is the nurse's duty to dress so as to be healthy. Her work demands health. There is no room in the ranks for the nurse who *"enjoys poor health."*

No Excuse for Nurses.

Let us all try to be healthy.

The Various Baths.

The Bath.—Nothing is more conducive to good vigorous health than proper and systematic bathing. Few things are more restful to the tired nurse when she comes off duty than a good warm salt bath before retiring. A pint of sea salt, or common salt, to each two gallons of water is a fair proportion. Take a good "rub" with a Turkish towel on emerging from the bath. A cold sponge bath should be taken in the morning when you rise. Many recom-

mend a cold "plunge" bath and find it very healthful when taken quickly and followed by a brisk rubbing, but it is a bath not suited to all constitutions. Those who find a cold plunge too severe, often enjoy getting into a tepid bath and gradually lowering the temperature until *it is cold*. A good soap and water tub bath several times a week is necessary to healthful conditions, in addition to "salt" baths, "sponges" and "plunges." When taking a bath after a meal, allow two hours to elapse before beginning operations.

Disinfect the Hair.

THE HAIR, THE TEETH, THE NAILS, ETC.—Take care of your hair and keep it well shampooed. Diseases can be communicated from one to another by *bacteria which fasten upon the hair, as well as upon the skin, beneath the finger nails and within the mouth.* Do not forget these points when carrying out personal disinfection during and at the close of nursing a communicable disease. Be especially careful when nursing a case where gonorrhoea or syphilis are suspected. Many good nurses' lives have been sacrificed or *ruined* by contracting these diseases through lack of care while nursing such patients. The toilet is never complete until the hair, the teeth and the finger nails are as immaculate as the dress and the rest of the person. Beware of diseased gums and decayed teeth. These admit pathogenic bacteria to

which many cases of joint diseases have been traced. Have your teeth carefully attended to by a good dentist at least twice yearly.

Obey the Calls of Nature.

Do not forget that neglect of Nature's calls leads to habitual constipation, cystitis and other evils allied to these. *Write this truth in capitals* upon your memories. It will save you lots of trouble.

A Mixed Diet.

FOOD AND WATER SUPPLY.—In order to keep healthy, food should not only be taken at regular intervals and in proper quantities, but it should also be of the most nutritious, easily digested and assimilated character. Pastry and sweets should be partaken of very moderately, if at all. The heaviest meal of the day should not come in the evening when the digestive system is tired from the exertions of the day and needs rest. A mixed diet, consisting of meat, vegetables, fruit, bread, eggs and milk, will be found more valuable, when planning for a healthful diet, than the cranky idea of living entirely upon vegetables or going to the other extreme and cutting them out of the food list entirely.

Water Supply.

Do not drink cold water, particularly ice-cold water, with your meals. It chills the stomach and retards digestion. The human structure requires plenty of water to keep the wheels of its complex machinery in good running order, but this water supply should be

Put the Pitcher in the Refrigerator.

taken in between meals and should be as pure as filtering and boiling will make it. Put the *pitcher containing the water on the ice instead of putting ice into the pitcher.* Few germs, if any, are entirely destroyed by freezing. They usually thaw out and again renew their activities. Typhoid fever and diphtheria germs have lived all winter in pond ice and in the spring and following summer were just as powerful as ever to spread infection.

Ventilate Your Sleeping Rooms.

REST AND SLEEP.—Do not sleep or rest in a stuffy, dusty, badly ventilated room. Remember to have between two and three thousand cubic feet of fresh air in all your sleeping rooms as well as in sick-rooms. This amount of air we have already said, when speaking of "communicable diseases," is found in a room twenty feet long by fifteen feet wide with a ceiling elevation of ten feet, provided the current of air is changed frequently to keep it pure. The windows should always be open at the top and, to aid in the regular changing of impure for pure air, open them up from the bottom for a while every day and open the doors also. Do not open your windows several inches higher than your window screens in hot weather, or remove the screens, thus admitting flies. Pick up a common house fly and examine it under the microscope. The common house fly has come to be called "the typhoid fly."* When

* See pages 8-9.

you see the numberless pathogenic bacteria on its feet you will not make this mistake again. Do not rest or sleep in a current of air. It is an injurious habit for even the most vigorous.

Remove Day Garments.

Do not sleep in any garment worn during the day. Learn to relax the muscles when resting. Do not sleep with a pile of pillows beneath the head; use only a small pillow. Better no pillow at all than to be held up in almost a sitting position all night, rounding the shoulders and making the chest hollow.

Untidy Nurses.

Keep your own room clean and neat. It is a matter quite surprising to find any number of nurses whose rooms look as if "a cyclone had struck them," and yet who would not be guilty of such negligence if they were more thoughtful of laws of health as applied *personally*. Where there is dust and other lack of cleanliness there, also, will *always be found disease germs*.

Let the Sunshine In

SUNSHINE.—Sleeping rooms and all rooms occupied by the delicate should be rooms with a southern exposure, so as to have the benefit of the sun's rays for the greater part of the day. Not only should we live in the sunshine as much as possible, but we should ourselves be *sunny*. The only place for the gloomy nurse is with the mercenary nurse, the bad-tempered nurse, the gossiping nurse, the untrustworthy nurse and the nurse who "enjoys poor health"

—outside the ranks. This thought is particularly applicable to those nurses who honestly desire to be successful. Those with a sunny disposition are always at a premium. What sick one can fail to love and desire to have about her the nurse with a "southern exposure." She fairly beams as she enters the sick-room, and no matter how plain her face this nurse always looks beautiful in the eyes of the sufferer, to whom she invariably seems to communicate sunshine, the power of which dissolves and drives away all gloomy forebodings. She cannot fail to cure the "blues," for the sorriest grumbler in the "slough of despond" on the sick list must needs feel ashamed of such moods in the presence of the sunny nurse.

The Sunny Nurse.

Let us all learn to let the sunshine into our hearts as well as to let it shine upon us. "Let the sunshine in" and it will radiate from the eyes and the smile of the good nurse; be felt in the touch of her gentle, kindly hand, and in the tones of her sweet, cheerful, hope-inspiring voice. Sunshine in the heart and in the soul leaves no room for the germs of the disease *sin*, which so often threatens to destroy our usefulness.

It is not only the blessed privilege of each nurse to be the *best nurse possible* and to be all

that is truest, purest and most perfect among women, but it is also *her duty*. May we each strive to grasp this duty as Heaven-born, so shall every nurse be beloved and in being beloved do her best and noblest work.

> "The world may sound no trumpet, ring no bells,
> The Book of Life the shining record tells."

SUMMARY OF CHAPTER VIII.

Ills brought upon the human structure by neglect of hygienic laws.

Fashions of bygone days opposed to laws of health.

Restrictions of society with regard to games, dress, and so forth, a thing of the past.

Forgetfulness on the part of the nurse with regard to hygiene may be the cause of a shortened period of usefulness. Following its precepts may lengthen the period.

How success is obtained by the good nurse.

Walking and dressing sensibly. The sensible dress the hygienic dress.

Keeping the uniform sacred to the sick-room, and why.

Bathing and when to bathe so as to be healthy. The care of the hair, the teeth and attention to Nature's calls.

Proper diet and sufficient water supply necessary to health.

Ventilation. Fresh air, sunshine and a sunny disposition and their effects.

SUPPLEMENT.

The "Side Chain Theory" of Ehrlich.

COMPARISON WITH "THEORY OF METCHNIKOFF"

SERUM THERAPY.

PART I.

In the year 1885, prior to the discovery of toxins and antitoxins and before scientific workers had discovered the real nature of immunity, from far-off Europe, Paul Ehrlich,* of the Royal Prussian Institute for Experimental Research at Frankfurt, sent forth to the world a small pamphlet, entitled "The Oxygen Requirements of the Body." In the course of argument therein, he gives the opinion that food assimilation by the body cells comes to pass only after the nutrient sub-

Hypothesis of Ehrlich.

* Prof. Paul Ehrlich died in Berlin August 20, 1915, of heart disease. Ehrlich was born at Strehlen in the Province of Silesia, March 14, 1854. He was educated in Breslau, and studied medicine at Breslau, Strasburg, Freiburg and Leipzig. He received his degree in medicine in 1878. In 1890 he was appointed assistant at the Institute for Infectious Diseases in Berlin under Koch, and was in 1891 made professor. In 1896 he became director of the Institute for Serum Study in Steglitz, near Berlin. He was made director of the Royal Prussian Institute for Experimental Therapy, a German government institute at Frankfurt, Germany, in 1899.

Prof. Ehrlich visited the United States in 1904 and lectured in several cities. He received the degree of LL.D. from the University of Chicago during his visit. In 1907 the University of Oxford conferred upon him

stances and the essential part of protoplasm have united chemically. He does not give us to understand that assimilation is at an end when this union takes place. He goes on to explain his belief that certain molecules of complex nature must divide, or split up, into very simple substances or particles prior to their entrance into the composition of protoplasm. In other words, the constituent part of the cell which unites with the food substance acts the part of a link to bring the food particles into intimate relation with the digestive activities of the cell. Ehrlich calls that part of the living protoplasm which represents cellular activity the central group of the protoplasm. The chemical groups which link or bind the food substances, he calls the "side-chains" of the protoplasm. The theory of Ehrlich assumes that the "side-

Cellular Activity.

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the degree of Doctor of Science. He received one-half of the Nobel Prize for Research in Immunity in 1908, the other half of the prize going to Prof. Metchnikoff, of the Pasteur Institute. Other honors conferred upon him were the Insignia of the Red Eagle by Emperor William XII. in 1914; the Grand Cross of the Order Civil de Alphonso from the King of Spain in the same year. A grand celebration was tendered to Ehrlich and his co-worker, Von Behring, on the occasion of their sixtieth birthdays, which were only one day apart (Behring's occurring March 15) when high honor was paid them both as two of the most famous scientists of our day. Ehrlich's early work was the study of the blood and its constituents; fundamental work in the standardization of diphtheria antitoxin, in conjunction with Von Behring; development of "the side chain theory," salvarsan and neosalvarsan in 1910 and 1911, and later on he was concerned with remedies for cancer.

chains" of a cell consist of clearly defined groups of atoms which are capable of uniting chemically with other definite groups of atoms in food particles. The side chains themselves he calls *Receptors.* To the uniting or combining groups of both the "side-chains" and the pabulin, or *molecular products* of food elements, he has given the name *Haptophores.* As the different foods have different chemical elements, Ehrlich believes they also have different binding (or combining) groups, (haptophores) and that there also must exist many kinds of receptors, each of which is able only to combine with that form of food substance which has a corresponding binding or combining group of atoms. Each special cell, as nerve or muscle, assimilates only that form of food suited to its own peculiar growth and development.

Pabulin.

Food Assimilation.

In a more recent announcement of Ehrlich he summarizes as follows:

"We must assume that all substances which enter into the structure of protoplasm are fixed chemically by the protoplasm itself. We have always distinguished between assimilable substances which serve for nutrition and which enter into permanent union with the protoplasm and those which are foreign to the body. No one believes that quinine and similar substances are assimilated—that is—enter into the composition of protoplasm. On the other hand, the food substances are bound in the cells and this union must be considered as chemical. One cannot extract a sugar residuum from cells with water, but must first split it off with acids in

Physiological Metabolism.

order to set it free, but now such a chemical union demands the presence of two binding groups of maximal chemical affinity which are suited one to the other. The binding groups which reside in the cells and which bind food substances I designate as "side-chains" or receptors, while I have called the binding groups of the molecules of food-stuffs the haptophores. I also assume that protoplasm is endowed with a large series of such side-chains or receptors, which through their chemical constitution are able to bind the different food-stuffs and thereby provide the prerequisite for cellular metabolism."

This theory naturally applies to physiological (constructive) metabolism. In *pathological* (destructive), metabolism we have the presence of an abnormal substance in the body juices which forms new haptophores. According to the "side-chain theory," the power of these substances to exert injurious effects within the body depends upon their ability to attach themselves to the cell receptors. In this way is explained the immunity of some animals to certain toxins, viz.,—they lack the appropriate receptors for the invading haptophores to combine with. Should the invading haptophore combine with a receptor, one of the following phenomena takes place:

Pathological Metabolism.

Immunity of Some Animals Explained.

(1.) The invading haptophore may so closely resemble the normal haptophore as to perform the function of the latter, and so no harm is done.

(2.) It may combine with neither good nor bad result, but may deprive the cell of its nutri-

tion by reason of its having displaced the *normal* haptophore.

Toxophorous Groups.

Haptophorous Groups.

(3.) It may be directly or indirectly injurious or destructive by means of an associated toxophorous (poisonous) group. It will thus be understood that toxins are conceived to be complex, composed of fixation or binding groups (haptophores) and poisonous groups (toxophores). The cells of the body Ehrlich believes to possess and to furnish appropriate receptor groups, haptophiles and toxophiles, through which the respective combinations are effected. But until the haptophore of the toxin has been taken up by the haptophile of the cell, the toxophore cannot attack the toxophile. He also believes a bacterium to be a chemical compound made up of two or more chemical groups, closely or loosely combined. When a bacterium enters the body and comes in contact with the lateral or "side-chain" groups of the body cell, the receptor (antitoxic), group combines chemically with the toxic group of the invading bacterium. If the chemical affinity between the toxic group and the receptor (antitoxic), group is greater than that between the toxic group and the remainder of the cell, it will split off and combine with the receptor of the body cell; thus toxins are liberated—set free to carry on their work of destruction within the body. The bacteria proper are disposed of by a

Chemical Composition of Bacteria.

Liberation of Toxins.

splitting-up action of the blood known as "hemolysis." Two bodies are present in the blood. One body called the *complement* is normally present in the serum, the other is an intermediary body known as an *amboceptor* or fixiator. When the affinity between this group and a group contained in the invading micro-organism is stronger than the affinity to the remainder of its own cell it will split off and join the other body, (the amboceptor), forming an avenue for the passage of the *complement* which destroys the cell. The phagocytes are then supposed to remove the dead invaders and absorb or ingest them.

Hemolysis.

Amboceptor.

Complement.

Antitoxin, Ehrlich explains in the following manner: "When a useless haptophore attaches itself to an important receptor, it becomes necessary for the cell to form new receptors of a similar nature. When prolonged and repeated invasions of useless haptophores takes place an excessive production of receptors is formed, which finding no function detach themselves from the cells to form in the tissue juices new groups of molecules which have an especial affinity for the invading haptophores. These latter groups, the detached or cast off receptors, are the antitoxins."

Ehrlich's Conception of Antitoxin.

An investigator writes: "When one seeks to compare the 'side-chain theory of Ehrlich' with the theory of phagocytosis of Metch-

Ehrlich's Hypothesis Versus Theory of Metchnikoff.

nikoff, one finds but little in common. Notwithstanding this fact, it is rather striking that there are so few contradictions. Ehrlich's theory is one built upon chemical lines. That of Metchnikoff is founded upon *biological* principles. Each in a measure relates to *nutrition.* Metchnikoff only carries food substances into contact with the digestive ferments contained in the cell and there he leaves them. Ehrlich goes farther and teaches us how nutritive matter enters into and becomes a part of the protoplasm. Metchnikoff does not appear to concern himself with the structure of toxins, nor with the way in which they injure the cell. Ehrlich points out both of these factors. Metchnikoff believes that antitoxin is produced by phagocytic action on the toxin. Ehrlich presents an opinion entirely opposed to this. He believes antitoxins *to be produced by the cell itself.*

Metchnikoff's Conception of Complement Versus that of Ehrlich.

Both believe that amboceptors (fixiators) become extra-cellular in the blood. Metchnikoff asserts that complement is a substance which is produced by the phagocytes and that it is found in the plasma or serum of the blood, as a *result of injury to the phagocytes.* Ehrlich does not take up these points to any great extent, but some of the supporters of his theory believe that complement exists normally in the blood in the plasma.

"With regard to the action of antitoxins, Metchnikoff affirms that antitoxin stimulates the phagocytes to an increased absorption and destruction of toxins, while Ehrlich holds the opinion that antitoxin combines with toxin by a chemical process only. Metchnikoff believes that all types of immunity are dependent, either directly or indirectly, on the activity of phagocytes. *Ehrlich's 'side-chain' theory does not coincide with this view, yet it does not overlook the importance of phagocytosis in certain infections."

Work of Antitoxin a Chemical Process.

It has been demonstrated by scientists that recovery from some of the communicable diseases (for example, those due to the staphylococcus, streptococcus, and pneumococcus infec-

Phagocytic Power.

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* Ehrlich's "side chain theory" is briefly yet clearly stated in an editorial on the death of this wonderful man, in the Journal of the American Medical Association, August 28, 1915:

"A toxin (poison) or other antigen is without action on the animal body unless bound by molecular chains in the cells known as receptors. But when so bound the toxin causes injury to the cell. Subsequent repair, in the course of which there is an overproduction of receptors, which passing into the blood and limph, constitute the antibody for the toxin, because the toxin or other antigen is now bound and neutralized or else destroyed before it can reach the cell. As expressed by Behring, antibodies are free cell receptors, and the elements which, when situated in the cells are essential for the action of toxins, are also the means of healing when free in the blood. In accord with the principles of this theory, Ehrlich's vivid mind coined many new words which proved helpful in the discussion of new facts and theories, and these soon passed into current international usage."

tions) is not accompanied by marked antitoxic or antibacterial properties in the serum of the blood. On the contrary, an increase in the number of circulating leucocytes is found, which are known to be cells of bactericidal or phagocytic power.

Bactericidal Province of Serum.

In certain other diseases, for example, typhoid fever and diphtheria, just the opposite condition is found. It would seem therefore, from these investigations, that phagocytosis is of great importance in overcoming the invaders in the first group of diseases and the antitoxic and bactericidal province of the serum in the other.

PART II.

SERUM THERAPY.

Serum therapy is an attempt to combat the activity of certain pathogenic agents by the use of injections into man or animal of specifically antagonistic substances contained in or derived from the cells and body juices of animals artificially immunized against such infections. This process is known to the scientific world as *"direct serum therapy."* When in the tissues of man or animal antibacterial or antitoxic substances (antitoxins), are made to form, through vaccination or through protective inoculation, the process is spoken of as *"indirect serum therapy."* Both methods are used for either preventive or curative purposes. Serums are also used for the purpose of diagnosis in diseases due to bacterial invasion.

Serum Therapy Defined.

Direct and Indirect Serum Therapy.

Serums, in order to be effective, must be of a specified strength. In the early days of treatment of diphtheria by antitoxin, the low value of the serum made it of comparatively little effect unless used in very large doses, as the preparation contained only about twenty (20) antitoxin units per cubic centimeter. Many serums now-a-days contain more than 500 units per cubic centimeter.

Strength of Serums.

Antitoxic and other serums must be free from micro-organisms and toxins.

Purity of Serums.

The principles involved in serum therapy may be considered under three heads namely (*a*) Antitoxins, (*b*) Bacterial or antibacterial serums (c) and Vaccination. The terms, "antibacterial," "bactericidal" and "bacteriolytic" are frequently found to be used interchangeably. Strictly speaking this is inaccurate, as in the true sense of the term they are not synonymous. Bactericidal serums we, of course, understand to mean those serums which are able to destroy bacteria. If during the process of destruction, they are able also to *dissolve bacteria,* they are truly bacteriolytic. In either event the serum is *antibacterial.* In typhoid fever the serum *kills but does not dissolve* the bacteria. In cholera the action of the serum is *both to kill and to dissolve* the bacteria. Until recent years the action of toxin and the efficiency of an antitoxin could only be decided upon by experiments on the living subject. These experiments are still kept up, but not exclusively, as the nature of the action of the antitoxin could not easily be determined *by this method alone.* Since the introduction of test-tube experiments into laboratory work, some of the difficulties which existed have been removed. There are still differences of opinion among authorities, as to whether antitoxin combines chemically with toxin, or whether its protecting (immunizing) power is due to its

Inaccurate Use of Terms.

"Bactericidal," "Bacteriolytic" and "Antibacterial" Explained.

Experiments.

Authorities Not in Unison.

stimulating effect on animal tissues. Behring, of Germany, in the year 1890, who, in conjunction with Ehrlich, was the discoverer of antitoxin treatment in diphtheria, has always asserted his firm belief in the theory of chemical union. Other investigators, among them Metchnikoff, the discoverer of phagocytosis, take exception to this view. These men hold the belief that "antitoxins stimulate the phagocytes to an increased *absorption* and consequent *destruction* of the poisons (toxins) of bacteria. Each of these theories has its own exponents among the most learned workers of the present day. The value of the activities of the phagocytes in certain disease is acknowledged by investigators along this line. As to the opsonins, it has been developed through these investigations, that "the work of the phagocytes as destroyers and ingestors of bacteria is greatly increased by these properties (opsonins) contained in the serum of the blood" (Wright).

Behring Sanctions "Chemical Union."

Exception Taken by Other Workers.

(A) *Curative Injections.*

In passive serum therapy (passive immunization) (1) injections are given with antitoxic serums, namely those of diphtheria, tetanus, plague, tuberculosis, typhoid and streptococcus infections.

Antitoxic Serums.

(II) With antibacterial serums; namely, typhoid, cholera, plague, dysentery, streptococ-

Antibacterial Serums.

cus, staphylococcus and pneumococcus infections.

(B) *Curative Injections.*

Antibodies Explained.

In active serum therapy (active immunization), injections of bacteria killed by heat are given in small doses for the purpose of hastening the formation of the *characteristic constituents of the blood* and other fluids of immune animals known as "*antibodies,*" or antidotes.

(A) *Prophylactic* (Preventive) *Injections.*

Vaccination.

Active immunization consists of vaccination and protective inoculations with the killed organisms of typhoid fever, cholera and plague. Depending upon the material injected, the result gained is the formation of an antitoxin or antimicrobic substance known as an "amboceptor" or "fixiator." (Quoted words coined by Ehrlich.)

(B) *Inoculation With Virulent Organisms.*

(I) Used principally in experimental work. Inoculations are given with a small amount of the micro-organisms, that is to say, "a nonfatal dose."

(II) Inoculation with virulent organisms into a tissue which has some material resistance. In the early days of vaccination, virus taken directly from those suffering with smallpox was used. The success of the method is believed

to be due, in all probability, to unfavorable conditions found in the skin which prevented the development of virulence.

(I.) INJECTIONS OF ATTENUATED * (WEAKENED) VIRUS.

Injections of attenuated virus are given in order to establish resistance against a suspected infection.

(II.) INJECTIONS OF KILLED ORGANISMS.

This process is said to be the safest way to vaccinate against typhoid fever, cholera and plague. In the Pasteur Institute treatment of hydrophobia, in the first treatment given, dried spinal cord is the material used and it is believed to contain killed virus.

Principles of Serum Therapy Considered.

For the sake of brevity and to simplify for study, the principles of serum therapy may be considered under three heads—namely:

1. Antitoxins.
2. Bactericidal or antibacterial serums.
3. Vaccination.

We have already mentioned the chemical union of toxin and antitoxin, which is believed

* Various methods are employed for the attenuating (weakening) of virus, viz.: By drying. By growing the virus at a temperature unsuited to the development of virulence. By passing the virus through a less susceptible animal. By the use of chemicals, such as iodin, as used to be done in diphtheria toxin. Or by means of heat.

by many authorities to bring about neutralization.

Test Tube Experiments.

Mixed in a test tube at a given temperature and of a certain concentration, these authorities tell us that union takes place rapidly and completely, provided the requisite degree of affinity exists between the two substances used. There is no third substance present with which one or the other of the materials used may combine.

Union of Toxin with Antitoxin and with Body Cells.

Within the body conditions are different, and we are taught that one of two combinations may occur. The toxin may unite with the antitoxin injected into the body, or a second combination is possible, viz., the toxin may unite with the tissue cells.

Experiments of Heymens with Tetanus.

Union with cells, according to the demonstration of Heymens in his work with tetanus, is often a very rapid and complete one.

"Heymens found that if all the blood were removed from an animal *a few minutes after the injection of* a single fatal dose of tetanus toxin and the blood of another animal substituted, still it would be found that *the animal died of tetanus.*"

Experiments of Other Scientists.

All the toxin had combined with the cells in that short time. Experiments of other workers tend to demonstrate not only that the toxin may combine with the tissue cells very rapidly, but they also make clear the manner in which antitoxins bring about a cure. Interesting experiments by scientists with regard to the disease,

tetanus, have brought to light the knowledge that if the antitoxin is injected into the animal body four minutes later than the toxin, a slightly larger than the neutralizing dose is necessary to prevent tetanus symptoms from developing. If eight minutes were allowed to elapse, six times as much antitoxin is required. After sixteen minutes, twelve times as much antitoxin must be used. After the lapse of a few hours *no matter how much* antitoxin is injected *the life of the animal is forfeited.*

Diphtheria Toxin and Antitoxin.

Experiments with diphtheria toxin and its neutralization by antitoxin in the animal body developed similar conditions. Practical experience with diphtheria in the human subject has demonstrated that the longer the disease has been in progress the more antitoxin is necessary to effect a cure.

Curative and Prophylactic Treatment.

The curative action of an antitoxin does not consist in the neutralization of the circulating toxin, but rather in its being able to "*tear away from the tissue cells the toxin they have taken up," or "bound."* In course of treatment, the circulating toxin "is neutralized." This step is prophylactic (preventive) in nature and only an equivalent of toxin is required. But a *great excess is required* in order to remove toxin from tissue cells. Authorities assert that when no amount of antitoxin will effect a cure, something more than chemical union between the

toxins and the body cells has taken place. Processes of a biological nature have arisen by reason of which the toxin becomes a part of the protoplasm and destructive action of the toxophorous (poisonous) group has probably begun.

Destruction by Toxophores.

It is important for students to remember that it is *not believed* that antitoxin can repair an injury toxin has already accomplished. "Repair is *dependent upon the recuperative power of the cells themselves.*" Curative properties are exercised by reason of the power of antitoxin to wrest or take away forcibly from the cell so much of the toxin that *less than a fatal dose* is left in the cell.

Cell Recuperation.

There are two points which are important to remember in the study of antitoxin curative treatment.

Early Administration of Antitoxin.

(1.) That the antitoxin must be administered early in the case, viz., before the toxins have combined with tissue cells.

Toxin Neutralization.

(2.) That a sufficient quantity of antitoxin must be administered in order to overcome or neutralize the toxin.

The study of the diseases tetanus and diphtheria and their comparison have brought to light many important facts concerning the principles of serum therapy.

Diphtheria Antitoxin Curative Properties.

It has been found that diphtheria antitoxin has very much greater curative properties than

tetanus antitoxin. In the test tube, the affinity between the toxin of tetanus and its antitoxin is weak, apparently. Ehrlich found that "it takes forty (40) minutes to bring about complete neutralization in the test tube," while it has been shown by the experiments of others that "the affinity of tetanus toxin for the nervous tissues is very strong, all the toxin *being absorbed* in a few minutes." These facts demonstrate that the curative value of the tetanus serum must be low. On the most vital of all organs, *the central nervous system and the spinal cord,* the tetanus toxin has proven to have marked selective action. For this reason a lower grade of injury may prove fatal in this disease than in other infections where less important organs (or those of greater recuperative power) are affected. The theory that the tetanus toxin is *"taken up by the nerve endings* and reaches the ganglionic cells by way of the axis cylinder, where it is in a manner isolated and is scarcely accessible to the action of the antitoxin" (which remains, for the most part, after injection, in the blood and lymphatic circulation), has given place to the belief that "the reason for failure in the use of tetanus serum is probably due to the powerful affinity of tetanus toxin to the cells of the spinal cord. The damage is done before the antitoxin can be administered. In accidents in the laboratory,

Tetanus Toxin Affinity.

where enormous quantities of pure cultures have gotten into open wounds, the prompt adminstration of serum has prevented development of the toxemia.

Diphtheria Antitoxin Affinity.

With regard to diphtheria: The degree of affinity between toxin and antitoxin is much stronger in this disease than is the affinity between tetanus toxin and its antitoxin. Complete neutralization in the test tube takes place in fifteen minutes. Chemical tests have demonstrated that the affinity of diphtheria toxin for tissue cells is not nearly so great as is that of tetanus. Diphtheria has been cured by the toxin treatment on the second day, while cures effected in tetanus cases are to say the least *not common.* The toxin of diphtheria does at times affect the nervous system and cause paralysis, but this condition in diphtheria does not often prove fatal. Chemical experiments have shown that the toxin of this disease is so situated in the body as to be easy of access for the antitoxin.

I. IMPORTANT POINTS TO BE REMEMBERED in Serum Therapy are:

(1.) Strength of the antitoxin injected.

(2.) Freedom from bacteria and other contamination.

(3.) Time of administration, (early in the case).

(4.) Quantity injected.

(5.) Degree of affinity between toxin and antitoxin.

(6.) Degree of affinity between toxin and tissue cells.

(7.) Amount of toxin taken in ("bound") by the tissue cells outside of a fatal dose.

(8.) Location of the toxin in the body and the degree of accessability for the toxin.

Antitoxin Preventive Treatment.

The action of antitoxin as a prophylactic (preventive) treatment is much simpler than when used for curative purposes. The conditions resemble test tube experiments. There has been opportunity for the antitoxin to be distributed by the blood and lymphatic circulation before the invasion of bacteria and the production of their toxins. It is able for this reason to meet and combine with the toxin before it reaches the receptors of important cells. The high value which tetanus antitoxin as a prophylactic has attained in recent years is in all probability dependent upon this condition.

Duration of Immunity.

The immunity afforded by administration of antitoxin for prophylactic purposes is short, usually lasting only two or three months. While some of it may be "bound" by the tissue cells, a great deal of it is believed to be *excreted in the urine.*

II. ANTIBACTERIAL, OR BACTERICIDAL SERUMS.

Endotoxins.

Investigators have found a large group of organisms, which contain toxic products, associated with the protoplasm of certain microbes. These toxic substances are called endotoxins.

Some of the bacilli in which the endotoxins are found are those which cause typhoid fever, dysentery and cholera. The endotoxins of the bacilli of these diseases cause strong antibacterial serums to form in immunized animals.

Antibacterial Serums Investigated.

Antibacterial or bactericidal serums do not neutralize toxins. It has not been proven definitely whether the opsonic or bacteriotropic substances which stimulate phagocytosis are of importance in order to bring about the vital action of antibacterial serums. While experiments in test tubes have demonstrated antibacterial serum to be able to kill bacteria, experiments in the animal body have shown them to be much more reliable as preventives of infection than they are as curative agents. Immunity conferred by antibacterial serums is of short duration, lasting only two or three weeks.

"For this reason they are more useful as prophylactics in man when used in combination with vaccination. In saving the lives of animals which have been experimented upon, antibacterial serums have proven efficient,

provided they are injected *in advance* of the bacteria, or *at the same time,* or within a few minutes after the bacterial injection."

Antibacterial serums are not *antitoxic.* In this connection the question naturally arises: Why are there no antitoxic serums for some of these infections? The answer of investigators is: "Because of:

I. The difficulty in liberating the toxins from the bacteria.

II. The difficulty of forming proper relations between the amboceptor and complement.

III. The inaccessibility of the antitoxin to the germ, as in cholera."

III. VACCINATION.

Immunizing Power of Vaccination.

Vaccination against smallpox is a preventive treatment discovered by Dr. Edward Jenner of England. He demonstrated successfully its immunizing power in the year 1796, several years after his discovery. Jenner was born in Berkeley, Gloucestershire, England, in 1749. He died in 1823.

We have all grown familiar with the term vaccination as applied to the prophylactic treatment of smallpox. By the vaccination process the immunity gained extends over a protracted period; sometimes for life. It is taught by

some authorities that in consequence of vaccination the cells of the body have been

Trained Body Cells.

"trained to produce the corresponding receptors and that when subsequently micro-organisms gain an entrance to the body antibodies form rapidly and overcome the invaders in their incipiency."

In smallpox we do not know the etiological agent, therefore we cannot produce a specific serum but must use the whole virus in the form of a vaccine.

Protective inoculation, or in other words, vaccination is now-a-days used to protect against diseases other than smallpox and with equal propriety. Attenuated, or killed virus of a disease is inoculated and resistance to an infection is established. Hydrophobia is treated by inoculation as is also typhoid fever, plague, cholera, dysentery, etc. Protection (immunity) is not established immediately. We are familiar with the fact that in vaccination against smallpox infection, several days elapse before immunity is gained. This is also true of vaccination or inoculation against other diseases. Wright of "opsonic theory" fame, calls this period between vaccination and the time when immunity is gained "the negative phase." The period following the formation of protective properties in the subject treated he calls "the positive phase." The length of time of the negative phase is dependent upon the nature

Diseases in Which Vaccination Is Used.

Negative Phase.

Positive Phase.

and the quantity of the virus injected. We do not know the nature of *all* protective products. If the micro-organism which causes the disease is unknown it is not easy to determine what protective products are formed by inoculation, or vaccination. In the diseases typhoid fever, cholera, plague and dysentery the protective agents formed are known as "bactericidal amboceptors." (Ehrlich.)

Protective Agents.

ANTIMENINGITIS SERUM.

Method of Preparation:

"The serum used in the treatment of cerebrospinal meningitis is prepared from horses which are first carefully examined to ascertain that they are in good health. They are then treated by injections of killed meningococci alternated with injections of cultures of meningococci which have undergone autolysis.* The injections are given alternately every few days. After a few weeks the killed meningococci are replaced by living organisms the number of which is steadily increased. The injections are given as before, alternately with autolized cultures."

Health of Animals.

* Autolysis is obtained by pouring from ten (10) to twenty (20) c. c. of sterile normal saline over the surface of a twenty-four hour culture of the meningococci. The flask is gently moved from side to side until the cultures are partly separated from the media. The flask is then returned to the thermostat for another twenty-four hours.

Duration of Treatment.

These injections are kept up for about six months (in some cases for a greater period), after which the serum of the horse is tested. If it shows bacteriotropic power in a dilution of 1 to 5,000 it is considered to be sufficiently strong to be of value for therapeutic purposes. If the serum in this dilution does not act, the treatments are continued until such power is gained.

The efficacy of the serum treatment of cerebrospinal meningitis has been proven by the following facts gathered from statistics:

1. Diminution of mortality.
2. Influence on the symptoms in each particular case.
3. Reduction of the duration of the disease and the rarity of after-effects.

DIMINUTION OF MORTALITY.

The French Epidemic.

Statistics give the mortality from cerebrospinal meningitis in different epidemics at from 30 to 90 per cent. In infants 100 per cent.

In 1909, during an epidemic in France the mortality rate was remarkedly decreased by serum therapy. 402 cases were reported, with 66 deaths; a mortality of 16.44 per cent. In nineteen of these cases the patients were either in extremis when the injections were given or death was caused by some complication. Cases

treated during the same epidemic, without serum, showed a mortality of 65 per cent.

Reports show that the best results were gained by early injections of the serum. Mortality in cases treated before the third day was less than one-third that of those where treatment began after the first week.

INFLUENCE ON THE SYMPTOMS.

All the symtoms were very markedly reduced in from twenty-four to forty-eight hours after the intraspinal injections of the serum, as a general rule. First symptoms relieved are coma, headache, delirium and insomnia; temperature falls and sometimes becomes normal. The fall of temperature and lessening of other symptoms may come by lysis or by crisis. Stiffness of the neck may persist longer than the other symptoms although it is usually relieved. Some cases are very little benefited by the serum, others not at all.

First Symptoms Relieved.

Sometimes the treatment is undertaken when too late. Or the disease may be of the septic type. Cases in which the disease is confined to the cranial region, which the serum can only reach with difficulty, are not apt to yield to treatment. Another type not benefited is the chronic type. Lesions are believed to be located in the vertex or in the ventricles of the brain and so are not so accessible to the serum.

Failures Explained.

Influence on Symptoms.

Stubborn cases lasting several weeks are not so frequently found as they were before the introduction of serum therapy. Convalescence is shorter and less marked by listlessness, the drawn and lifeless appearance of the face, etc. The infrequency of after-effects is believed to be due to the use of the serum not giving them time to develop. In many epidemics such after-effects as deafness, blindness and paralysis have been as high as 75 to 80 per cent. Since the introduction of serum therapy, statistics report 2.56 to 7.05 per cent. Complications have not arisen in any case where they were not already present before treatment began.

Introduced into the spinal canal, the serum acts:

(1) directly on the meningeal lesions, and

(2) at a distance on the general organism.

Field of Operation.

Authorities emphasize the necessity for injecting the serum into the subdural space and of using sufficiently large doses. 30 cubic centimeters is the maximal dose, except in very young children (infants) and in cases where only a very small quantity of spinal fluid can be withdrawn and an obstacle is encountered. Usually the serum passes readily into the spinal canal. It is injected either by gravity, using a rubber tube with a needle attached and connected with a funnel, or by the use of a syringe.

It is essential to remove as much spinal fluid as will equal the amount of serum injected, as a rule. The patient's head may be lowered a little after the treatment to induce the spread of the serum into the skull.

Method of Injection.

Four injections of the serum are given at intervals of from twelve to twenty-four hours, even though the diplococci disappear from the spinal fluid and the symptoms clear up. The treatment is kept up longer than four days if the diplococci have not entirely disappeared. The injections are given slowly, not more than three (3) cubic centimeters in thirty seconds. General anaesthesia is prescribed during the treatment. Shock following the treatment is overcome by the use of strychnia and camphor, administered hypodermically. Dose, of course, to be prescribed by the physician in charge.

Number of Treatments.

Clinical reports of cases treated with antimeningitis serum during epidemics cover the years 1904-1909. The results obtained in the United States are not so marked as those obtained abroad. The epidemic in the United States had already passed the crisis when serum treatment was introduced. In some parts of Europe it was still raging. In Germany, as in this country, the epidemic was about over. In France, however, the serum was available at the outbreak of the disease and the mortality was less than twenty-five (25) per cent. The

Clinical Evidence.

Rockefeller Institute, New York, sent supplies to Professors Calmette, Netter and Roux.

Good results from the serum treatment are reported from Johns Hopkins Hospital, Baltimore, Garfield Hospital, Washington, D. C., and many other places in the United States and Canada.

DIPHTHERIA* ANTITOXIN OR ANTIDIPHTHERITIC SERUM.

As has already been stated on page sixty-nine, the use of antidiphtheritic serum or Antitoxin has reduced the mortality in diphtheria of from fifty to seventy-five per cent to three per cent, when used sufficiently early in the case. The serum should not only be given early, but in full doses of from three (3,000) to ten thousand (10,000) units, the number of units depending upon the severity of the case. The usual method of administration is by subcutaneous injections, but sometimes the injections are given intravenously in very severe cases.

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* H. K. Mulford & Company's method of preparation of the antitoxin of diphtheria:

"A virulent culture of the diphtheria germs is grown in pure culture on specially prepared media in incubators under conditions which are most favorable for the production of toxins. After growing from five to seven days tricresol is added to kill the germs, and after killing they are filtered out through a Berkefeld filter. The toxin is then tested for strength by determining the minimum fatal dose in a guinea pig of certain weight in a certain length of time."

Immunizing doses are also given to other children in the family, to the nurse and to any one else who may come in contact with the patient. The immunizing dose is, as a rule, about one (1,000) thousand units.

TUBERCULIN. (KOCH.)

Recently there has been a remarkable return of confidence in the use of tuberculin as a curative agent in tuberculosis. Koch, its discoverer, shortly before his death made the following statement:

"I maintain that its efficacy as a cure is completely proved provided its application be restricted to still curable cases; that is to those not too far advanced and not complicated by streptococci, staphylococci, pneumococci, etc.

Temperature Precautions.

"These processes are almost always accompanied by a rise of temperature and the best way to guard against the misapplication of tuberculin is to use it in cases in which the temperature of the body does not exceed 37° C. (98.6° F.). That tuberculin exercises an exceedingly favorable influence on all such cases and even completely cures them, as a rule, is a fact of which I have completely convinced myself. A number of medical men, who have studied the therapeutic value of tuberculin for years, and have either published their experience or have communicated it to me privately, have arrived at the same result."

While many specialists advocate the use of tuberculin even where the temperature runs up to 100° F., all advise the greatest caution in administering tuberculin to febrile cases.

Success Abroad.

Dr. Hammer, of Berlin, Germany, has employed tuberculin for several years in the treatment of pulmonary phthisis. "The injections were made in the suprascapular and intrascapular spaces, alternately on the right and left side. The skin was disinfected with alcohol, or alcohol and ether, as well as by thorough mechanical cleansing. Not a single abscess or infection was noted after any of the injections. The site of injection was protected with sterile cotton for twenty-four hours and the injection was made with a sterile syringe having a glass or metal piston." The dose must be carefully chosen in each individual case. The object Dr. Hammer has in view is just to avoid a reaction. His initial dose is from 1-1,000 m. g (milligram) to 1-100 m. g. He increases the dose very gradually.

Aseptic Preparation of Field.

Care in Administration.

Dr. Charles R. Kerley (Journal of the American Medical Association, 1909 Vol. II, page 1179), in an article on vaccine and serum therapy in children, states, in regard to the dose of tuberculin, that the dose of crude tuberculin administered for the purpose of immunization in a chronic tuberculosis lesion, should be very small—1-5,000 of a milligram gradually increased to 1-2,000, 1-1,000 or more. The inoculations should be repeated not oftener than every ten days at first and the temperature

taken every two hours. Should a rise of temperature occur, the dose is too large and must be reduced at the next injection. In selected cases, Dr. Kerley has had good results from tuberculin treatment in bone and joint disease and in adenitis. Many advocate the "opsonic index" as the best mode for determining the proper dosage. Others say the "opsonic index" is not valuable in this treatment.

Treatment in Bone and Joint Disease, Etc.

STAPHYLOBACTERIN.

(Staphylococcic Vaccine.)

Bacterins are suspensions, or emulsions of killed bacteria intended for therapeutic use.

Staphylobacterin is a suspension of killed staphylococci in normal saline solution, preserved with ½% phenol.

The bacteria are killed by heat at a temperature of 60° C.

Bacterins are only of value in infections caused by the same species and for this reason it is absolutely necessary that accurate diagnosis be made before beginning bacterin treatment.

Necessity for Accurate Diagnosis.

(1.) Diagnosis is made by examining the pus or other discharge under the microscope.

(2.) By preparing cultures from the pus or discharge.

(3.) By clinical phenomena.

Mixed Infections.

In some cases a mixed infection is discovered, when a vaccine of mixed bacterins is used. One mixed bacterin, is that consisting of mixed acne and staphlobacterin; another is the staphylo-bacterin associated with tuberculin. Still another is composed of staphylococcus albus, aureus and citreus. Difficulty in diagnosing such cases has brought into use the mixed bacterins. Dose varies from 25,000,000 to 250,000,000 staphylococci. It is conceded by authorities to be wise to start treatment by administering a small dose and to increase according to indications. If a proper size dose has been administered the patient feels better for an hour or two, then follows a period of depression with increase of the local symptoms. known as the "negative phase" (Wright). This should last a day or two, when improvement follows. The period of improvement runs from four to twenty days—known as the "positive phase." Should no "negative phase" occur, the dose is too small. If the "positive phase" is very severe, or should it last longer than three days, the dose is too large. The dose is not increased *so long as the "negative phase" continues.*

Dose.

Observation of Symptoms.

Bacterin by Mouth.

Administration of the bacterin by mouth has been discussed, but it is thought that not enough efficient work has been accomplished to make this method advisable.

The site of injection recommended is a point

from whence the lymph drains through or past the local lesion.

Dr. Hartwell of the Massachusetts General Hospital reports good results in that institution in the treatment of localized staphylococcus infections by bacterins.

Dr. Pray in the Edinburgh Medical Journal (1909), reports his use of the staphylococcus bacterins as a preventive of infection in surgical work. He believes that by this method he has also prevented post-operative pneumonia.

Bacterin in Surgical Work.

Many gratifying results have been reported through the medical journals and hospital bulletins by scientific workers who use the bacterins in their practice throughout the United States and Canada.

Other bacterins, the efficacy of which are rather firmly established, are the Acne-Bacterin and the staphyloacnebacterin. These bacterins have been the cause of much interest owing to the work of Professor Fleming, London, England, who has investigated their usefulness in St. Mary's Hospital, Paddington, W.

Acne Bacterin.

THE NEISSER BACTERIN.

(Gonococcic Vaccine.)

The treatment of gonorrheal infections by "bacterial vaccines" is also a recent method, and has been attended by considerable success.

Sir Almoth E. Wright demontsrated that subcutaneous injections of killed pathogenic bacteria produce in the blood and tissue fluids of the individual a substance (opsonin) which combines with the corresponding infecting organisms and so modifies them that the phagocytes readily take them up and ingest them (phagocytosis). The preparation of bacteria used for this purpose Wright calls bacterial vaccine."

The Treatment in Europe.

Dr. John Pardoe, Fellow of the Royal College of Surgeons, London, England, in an article written for the London Practitioner, January, 1908, stated that he had "seen the vaccine treatment of gonorrheal infections used not only in the subacute and chronic forms, but in the acute conditions, such as urethritis, and conjunctivitis, with such marked beneficial results as to justify a wider use of this method.

The Treatment in the United States.

Drs. Cole and Meakins in the bulletin of the Johns Hopkins Hospital, June-July, 1907, state: "In no case have we seen the administration of gonococcic vaccine do harm, and we feel that these cases offer sufficient justification for the treatment of gonorrheal arthritis by means of vaccine in doses of 500,000,000 to 1,000,000,000 gonococci, administered every seven to ten days." Other writers give similar opinions.

Opsonic Index Not Necessary.

Some authorities state that it is advisable although not absolutely necessary to control the inoculations by the patient's "opsonic index". Many others do not hold this view.

While gratifying results have been obtained both in the United States and in Europe by the bacterial vaccine treatment of diseases caused by gonorrheal infections, too much must not be expected of it in the way of *cure*. "With further work the limitations as well as the advantages of the method will appear. It should be used rather in conjunction with other general measures such as rest, aspiration of joints distended with fluid, massage, and other surgical and general hygienic treatment."

Wright's Method.

Following Wright's method, vaccines have been administered almost exclusively subcutaneously by hypodermic syringe. Wright believes that the injections should be made near the focus of infection and so located that the flow of blood and lymph is directed *toward* the point of infection. As Wright expresses it "the injection should be made "up-stream" in relation to lymph channels." For the most part the injections are given in the back, in the dorsal or lumbar region and in the groin. The site of the injection must be thoroughly cleansed and made aseptic in the usual way, and great care must be taken to use an absolutely sterile syringe. Nothing positive seems to be known

Site of Injection.

Dosage Varies.

about the size of dose to be administered and we find anywhere from 5,000,000 to 45,000,000 gonococci spoken of as injected in cases of children and 300,000,000 to 500,000,000 gonococci in adult cases, without (it is claimed) bad effect.

Dr. V. T. Churchman, Eye, Ear, Nose and Throat Specialist, on the Staff of the Charleston General Hospital, Charleston, West Virginia, reports a case of much interest. A male patient suffering with an infected eye and whose general condition was bad, was admitted to the Charleston General Hospital, June 7, 1910. A microscopic examination of the pus revealed the presence of the gonococcus of Neisser. It was found necessary to remove the eye in order to save the patient's life. His general condition was improved for a few days, but on June 19 his condition became so critical that all hope for his recovery was abandoned. Meningitis had developed. Serum treatment was resorted to. On June 20, staphylobacterin (staphylococcic vaccine) minims xx was used hypodermically. The patient's temperature prior to the injection was 100. A reactionary temperature of 102.5 followed. On June 21, very little, if any improvement was noted and an injection of Neisser bacterin, 50,000,000 gonococci was ordered, followed by a slight reactionary temperature of one-half a degree

(temperature had not dropped below 102°). June 23, the temperature dropped to 99.2 and the patient's general condition was very markedly improved. No further use of the bacterin was necessary. The patient made a good recovery, was discharged from the hospital July 4, went home to work and has had no recurrence.

Dr. A. A. Shawkey, on the Surgical Staff of the Barber Hospital, Charleston, W. Va., reports a very interesting chronic case due to gonorrheal infection, in which an abdominal operation was necessary, October 25, 1909. A ruptured sac precipitated a small amount of pus into the cavity. 100,000,000 gonococci of Neisser was injected immediately after removal from the operating table at noon. The next afternoon, 2 P. M., there was a rise of temperature from normal to 103.6. At 6 P. M. it had dropped to 101. At 10 P. M. temperature was 100. Twenty-four hours later it had dropped to 99°. Another 100,000,000 gonococci was injected, with reactionary temperature of one-half a degree. Repeated the dose of 100,000,000 for four successive days and then at intervals of two to four days. Practically no reactionary temperature occurred after the third injection. Pus drained freely for eight days. The entire number of injections (of 100,-000,000 each) was eight. The patient made a

splendid recovery and has had no recurrence. Among other bacterins receiving favorable consideration are the Pneumo-bacterin; the Typho-bacterin and the Neoformans-bacterin. The latter is recommended in cancer* to destroy odor and to allay pain, swelling and discomfort. It is not curative.

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* Autolysin, a new remedy for cancer, discovered and prepared by Dr. Alexander S. Horovitz, of Budapest and New York, and Dr. Silas P. Beebe, recently professor of experimental therapeutics at Cornell University College, while still in an experimental stage, seems to be awaking interest in a large number of cases, not only in New York, but throughout a number of other states. A description of the remedy was first published in the New York Medical Journal, May 15, 1915. Autolysin is given hypodermically and may not be given by mouth, as its organic constituents are decompounded in the digestive tract. It is a preparation containing chlorophyll and chromephyll in suspension, vegetable proteins and a variety of organic salts, extractive material, and liquids in sterile aqueous solution. It is prepared under the direct supervision of Dr. Horovitz at his New York laboratories. It may be secured by any legally qualified practitioner and is supplied in any quantity for the treatment of charity cases absolutely without charge. It is put up in aseptically sealed ampoules of one and two c. c. The usual dose is one c. c. (fifteen mimims), which is increased if necessary. A single dose daily or on every alternate day, or on every third day, according to the reaction and its effect on the tumor. The injections are given in the arm, usually; they may be given in another part of the body or may be given into the tumor, but there is said to be no advantage in that, as the action of the remedy is constitutional rather than local. If this remedy realizes the hope it has already awakened in the hearts of those who are afflicted with this dreadful disease, pen may not describe the joy it will bring. Dr. Hugh J. Nicholson, of Charleston, W. Va., among many others, speaks enthusiastically of this remedy, as used for his own cancer patients.

Experts in 1920 consider this remedy of doubtful value.

Since as early a period as 1896, when Pfeiffer, of Germany, began his work of investigation, anti-typhoid inoculation has been advocated. To Sir Almoth E. Wright, however, is due the credit for placing the method on a firm foundation. This he accomplished by his successful demonstrations among the soldiers in the British Army in India, and also in Africa during the Boer War. Since that period and up to the present year (1920)) the work has been successfully carried on in the British, the French and the United States Armies. The mortality rate has been decreased from 28.3 per thousand among the unvaccinated to 3.8 per thousand among the vaccinated. At Peshawur, India, Col. Skinner, of the Royal Army Medical Corps, reported an epidemic of typhoid fever that was cut short by using anti-typhoid inoculations in seventy (70) per cent of the command in connection with sanitary methods. Statistics, also, show that in cases (which are rare) where a patient who has been inoculated takes the disease, it runs a brief and very mild course.

Major Russell, of the U. S. Army, reported that up to June 1, 1910,* 8,510 persons had been treated by anti-typhoid inoculation. Among these very few serious reactions occurred. Not any bad results have been reported and there

*Many thousands more were treated during the world war and since.

had not been a single case of typhoid fever among the vaccinated, while among the unvaccinated there were some two hundred (200) cases in the same period.

From various hospitals throughout the United States and Canada come reports of favorable results obtained by the use of the method in the hospital and outside among physicians and nurses in order to produce immunity. "Typhoid carriers" have also been successfully treated. There have been no bad results and very few severe reactions; even these have entirely disappeared within forty-eight hours or less.

The object sought in anti-typhoid vaccination is to produce within the human organism substances which are antagonistic to the bacillus typhosus and which will destroy it. By this means the person treated is brought into a condition similar to that of a patient who has recovered from the actual disease.

The anti-typhoid vaccine is prepared from a typical typhoid culture which is grown on agar slants for twenty-four hours and is then washed off into a small portion of saline solution. It is tested for purity, placed in tubes (one-fourth of one per cent of tricresol is added as a safeguard), sealed, and the bacteria killed by heat at 60 centigrade for one hour.

The vaccine used in the U. S. Army is tested on at least two of the lower animals before use in man. All aseptic precautions are strictly observed before giving the inoculations. These are given subcutaneously in the arms as a rule at the insertion of the deltoid muscle. Aseptic precautions are also observed with regard to syringe, needle and vaccine container used in giving the treatment. The method most in use is to give three doses ten days apart. A lesser number of doses does not afford protection. The first dose five hundred million and the second and third one thousand million each. The treatment is given late in the evening, so as to lessen reaction. The reaction consists of headache, malaise, and in very severe cases (which are rare) nausea and vomiting, herpes labialis and albuminurea. Even in these severe reactions all such symptoms disappear in forty-eight hours. Immunity or protection is afforded for a period lasting from one to two years.

Local reaction is manifested by a redness and tenderness in the area about the site of the puncture and sometimes tenderness in the axilliary glands. The concensus of opinion seems to be that anti-typhoid inoculations have come to stay and that the success of the treatment is assured. Also that the day is not far distant when other serums and bacterins which hitherto have not been so successful will be

perfected and their use adopted throughout the whole civilized world. Anti-typhoid vaccine is also used during the course of the disease for its curative properties.

BUBONIC PLAGUE VACCINE.

The bacillus pestis is grown upon broth in the process of producing this vaccine. It is allowed to grow for several weeks (5 to 6). The culture is then heated to the point of sterilization. It is tested upon field mice in order to prove that it is sterile, after which it is ready for use in the human family.

BUBONIC PLAGUE ANTITOXIN (SERUM OF YERSIN).

This serum is prepared by a method very similar to the method used in the preparation of the antitoxin of diphtheria. Fresh cultures of the bacillus pestis are first sterilized by heat, and then injected into horses, first in very small doses, which are gradually increased until immunity or protection is assured. The same length of time is required to produce this serum or antitoxin as is required in the production of the diphtheria antitoxin. It is injected subcutaneously and the dose is from 60 to 150 cubic centimeters. This antitoxin must, also, be administered early in the case in order to be effective.

The bubonic plague serum or antitoxin is also used as a prophylactic measure, but immunity is short-lived and has to be repeated every two weeks. Bubonic plague vaccine is sometimes prescribed with the serum or antitoxin in order to prolong the period of immunity.

ANTISTREPTOCOCCIC SERUM.

Opinions of scientists with regard to the value of antistreptococcic serum differ very widely so far as its use in treating human infections is concerned. Some investigators have found it useful in lowering the temperature, improving the general condition and shortening the course of diseases in which the streptococci are known to be either the primary cause or in which they exist as a complication. Scarlet fever and acute rheumatism, for example, are among the latter diseases.

Bacteriological examination is necessary to prove that the streptococci are either the cause of the disease to be treated with the antistreptococcic serum, or that they are present as a complication.

In our medical journals, hospital bulletins and from reports of physicians in private practice we find arguments both for and against the use of the antistreptococcic serum as a

therapeutic measure. Like other inoculation substances, it must be used by those who are up-to-date in bacteriological processes before its real value shall be satisfactorily determined.

Among the diseases in which antistreptococcic inoculations have proven to be of great value when used by expert practitioners are the following: Chronic osteomyelitis, chronic eczema, cystitis, urethritis, peurperal septecaemia, scarlet fever, general sepsis, post-operative infections and septic wounds.

The best results have been obtained in chronic and acute localized infections.

The concensus of opinion of expert scientists is that antistreptococcic inoculation acts beneficially either as a protection or as a cure by increasing phagocytic activity and thereby strengthening this, the body's principal stronghold of resistance within the blood, against the advances of the specific germ or micro-organism, the streptococci, in its various forms.

ANTIPOLIOMYELITUS SERUM.

During and since the epidemic of poliomyelitus in the United States in 1916, an antipoliomyelitus serum produced by inoculating horses with the streptococci found in poliomyelitus, seems to abort the disease.

The method used for immunizing horses in the production of antimeningitis serum and antidysentery serum is followed in producing the antipoliomyelitus serum.

Whether or not this disease is due to streptococcic infections, has not been fully proven; but streptococci have been found quite constantly in the brain and cord and spinal fluid of patients suffering from the disease.

The use of the serum of the blood of persons who recently have recovered from poliomyelitus, is advocated by some investigators in the treatment of patients.

INFLUENZA VACCINE.
(LIPOVACCINE).

Prophylactic inoculations with a mixed vaccine containing freshly isolated strains of the bacteria found in influenza cases were used during the epidemic of 1918-19, with varying results. Also, in the later outbreak during 1920. Some investigators claim good results from the use of the vaccine, especially as a protection against the virulent form of pneumonia which was a complication of so many thousands of the influenza cases. Three inoculations were given. The vaccine contained several types of pneumococci, streptococci and staphylococcus aureus. The doses were large and the inoculations were given one week apart.

Only about one-third of those who were vaccinated developed influenza, it is said. It is claimed that the mortality rate in those who received three inoculations of the vaccine, even though they afterward developed influenza, was only about one-fifth that of the uninoculated. That the protection gained is short-lived, even the strongest advocates admit.

INDEX.

A.

B.

E.

F.

G.

H.

I.

K.

O.

P.

R.

S.

T.

U.

V.

W.

Y.

Z.